



Home Office

# Body Armour Standard (2017)

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# Summary

The Home Office has published test standards to assess the performance of body armour for over two decades dating back to 1993. In the intervening period, much has changed both operationally and from an engineering perspective in the ability to produce test methods that are more representative of the operational scenarios faced by end-users.

The Home Office Body Armour Standard (2017) outlines the minimum performance requirements and test methods for body armour intended for UK law enforcement agencies.

The requirements for this standard were derived from a series of consultations with stakeholders including the National Police Chiefs Council (NPCC), the Police Federation, end-users, manufacturers of body armour, accredited test facilities, the Metropolitan Police Service (MPS) Physical Protection Group and other technical experts.

The key requirement for body armour is to reduce the risk of death or serious injury to the wearer from ballistic or stab attack to the torso in normal operational usage.

Key improvements from the *HOSDB<sup>1</sup> Body Armour Standards for UK Police 2007* include:

- **Formed armour testing:** anthropometrically derived test surrogates, more representative of the morphologies of the female torso, enabling enhanced assessment of female body armour.
- **Ballistic protection levels:** an updated set of ballistic protection levels with test rounds reflecting the current operational requirements of UK law enforcement.
- **Rifle testing:** anthropometrically derived male front and back torso surrogates for ballistic testing to provide enhanced assessment on the performance of rifle protection.
- **Production quality testing (PQT):** introduction of critical perforation analysis (CPA) as a quality assurance tool to provide increased confidence in the continued production quality of soft armour.
- **In-life monitoring (ILM):** periodical assessment of in-service body armour over a period of time to ensure performance is maintained.

Special acknowledgements are given to Dr Sam Ellis and Mike Hicks at the Defence Ordnance Safety Group (DOSG) for the development of the perforation analysis tool based on original work conducted by the MPS Physical Protection Group. Further thanks must also be given to Mark Helliker of the Defence Science and Technology Laboratory (Dstl) for his advice and support on ballistic elements of the standard.

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<sup>1</sup> Home Office Scientific Development Branch, which became Centre for Applied Science and Technology (CAST) in April 2011.

Supplementary to the standard is a guidance document entitled *Home Office Body Armour Standard (2017) – Guidance*. This document has been written to be used alongside the standard and provides information to enable informed decision making in the selection and procurement of body armour and inform elements of best practice associated with its use.

# Nomenclature

Angle of incidence	The angle formed between the bullets intended line of flight and the perpendicular to front surface of the backing material at the point of impact.
Areal density	Mass per unit area ( $\text{kg.m}^{-2}$ ).
Armour carrier	The outer garment that contains the protective panels and holds them in the correct position against the body.
Armour cover	Cover immediately encapsulating the protective panel.
Armour model unique identifier	Unique reference given to a specific certified armour construction. This may be referred to as an 'armour model' in this document.
Associated panels	Unformed protective panels, of the same construction as formed armour.
Back face signature (BFS)	The maximum depth of indentation made by body armour into ballistic backing material after impact, measured perpendicular from the surface of the backing material.
Backing material	Test medium positioned behind armour in ballistic, knife and spike tests.
Batch	A single complete production run of a given armour model.
Batch reference	Unique reference given to a batch of certified armour.
Body armour	A complete construction of protective panels, front and rear, that provides protection within its coverage area. This may be referred to as 'armour' in the document.
Body side	The side of the protective panel that must be worn against the surface of the body.
Construction	A combination of constitutive materials from a protective panel for a given armour model.
Critical perforation analysis (CPA)	Test method to identify the velocity associated to a given statistical probability of body armour perforation.
Declaration of construction	Document, signed by the manufacturer, that declares the construction of a given armour model.
Design	The shape or style of a specific construction of protective panel.
Development testing	Any test work conducted by a manufacturer in the development process of body armour.

Extended coverage panels	Additional panels of armour, of the same construction as unformed armour, intended to provide protection to areas other than the torso.
Extreme temperature testing	Testing of armour after pre-conditioning in an extreme temperature environment.
Fair strike	An impact that adheres to the specified minimum acceptable criteria in terms of strike placement and velocity requirements.
Feathering	A gradual step down of armour layers around edges to enhance conformance, comfort and fit of the armour.
Formed armour	Shaped panels of body armour which are not flat; typically designed for females.
Fragmentation	Small high velocity projectiles; often generated as a product of an explosive event or disintegration of a ballistic round.
Held	Non-perforation of armour as a result of ballistic, knife or spike testing.
In-life monitoring (ILM)	Periodical testing of in-life armour to check continued operational performance.
Investigation	An examination of non-conformance to production quality testing requirements or in-service failure.
Pencilling	A narrow indentation of soft body armour into the ballistic backing material in instances where the armour has not been perforated.
Penetration	Any impact that results in the entry of an object through the strike face of the armour.
Perforation	Any impact resulting in a complete breach of the armour.
Plates	Hard armour designed to protect against specific test rounds, typically rifle and shotgun.
Production quality testing (PQT)	Periodic testing of certified armour to ensure production batches continue to perform at certification levels.
Product life expectancy	Duration over which protective panel is specified to provide the protection level it is being tested for.
Projectile	A fired, thrown, or otherwise propelled object.
Protective panels	Constituent panels of protective material of a given construction, enclosed in an armour cover. This may be referred to as 'panels' in the document, unless stated otherwise.
Redacted technical file	Reduced technical file providing information to enable test facilities to conduct pre-test assessments and construction checks.
Shaped backing	Backing material shaped to represent human torso

	morphologies.
Soft armour	Unformed or formed armour without any plate elements.
Spall	Debris from the rear surface of the armour that is released as a result of a ballistic impact.
Stab dampers	Discs of closed-cell foam, fitted into the knife sabot that increase the duration of knife impacts making them more representative of recorded human biomechanical data.
Stab sabot	Device that supports the knife or spike in the guided-mass drop test assembly. This may be referred to as 'sabot' in the document.
Standalone	An armour intended to be worn independently of soft armour backing. Most commonly referred to in the context of plates.
Strike face	The surface of the body armour designated by the manufacturer to face the threat (the side oriented away from the body).
Technical file	Comprehensive document containing technical details pertaining to armour submitted for certification.
Test series	A set of fair strikes on a given protective panel.
Unfair strike	An impact that does not adhere to the specified minimum acceptable criteria in terms of strike placement or velocity.
Unformed armour	Flat panels of body armour.
$V_{TEST}$	Maximum velocity specified within a protection level (e.g. HO1: $365 \pm 10 \text{ m.s}^{-1}$ , $V_{TEST}$ : $375 \text{ m.s}^{-1}$ )
$V_{01}$	The velocity of bullet, for given armour, at which 1% of shots are predicted to perforate and 99% are predicted to be held.
$V_{50}$	The velocity of bullet, for given armour, at which 50% of shots are predicted to perforate and 50% are predicted to be held.
Wet testing	Testing of body armour after pre-conditioning submerged in water.
Yaw	The angular deviation of a projectile about its longitudinal axis.

# Abbreviations

BFS	Back face signature
CAST	Centre for Applied Science and Technology
CATRA	Cutlery and Allied Trades Research Association
CPA	Critical perforation analysis
DOSG	Defence Ordnance Safety Group
Dstl	Defence Science and Technology Laboratory
FMJ	Full metal jacket
HO	Home Office
HOSDB	Home Office Scientific Development Branch
ILM	In-life monitoring
InChI™	International Union of Pure and Applied Chemistry (IUPAC) International Chemistry Identifier
ISO	International Organisation for Standardization
JHP	Jacketed hollow point
KR	Knife resistance (protection level)
MPS	Metropolitan Police Service
MQT	Manufacturers quality testing
NPCC	National Police Chiefs Council
PQT	Production quality testing
SG	Shotgun (protection level)
SP	Spike resistance (protection level)
SPL	Single penetration limit
SSL	Single shot limit

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# 1. Introduction

## 1.1. Background

The Home Office have specified test standards for body armour intended for UK law enforcement for over two decades. These standards detail test methods and minimum performance requirements for body armour to provide levels of knife, spike and ballistic protection, primarily to the torso region.

The first Home Office Body Armour Standard was written in 1993 and there have been three subsequent iterations published in 1999, 2003 and 2007. In each standard, a number of changes have been made in order to develop tests that are more consistent, practical, and representative of current operational threats to UK law enforcement. Notable features of each of these standards have been summarised:

- 1993** The first standard published by the Home Office, addressing knife threats for body armour. Revised in 1995 to cover ballistic threats.
- 1999** Major revision to the 1993 standard including the introduction of a guided-mass knife drop test; composite knife test backing material; non-edged spike testing; and, tiered protection levels to address a range of severities of knife, spike and ballistic threat.
- 2003** Introduction of a HG1/A ballistic protection level with additional permissible back face signature (BFS) to hand gun threats.
- 2007** Major revision of the 2003 standard including increased protection levels to address more powerful hand gun (HG3) and rifle (RF2) weaponry; in-production manufacturers quality testing (MQT); and increased number of knife, spike and ballistic compliance tests.

The Home Office Body Armour Standard (2017) supersedes all previous Home Office Body Armour standards. Any certification to previous standards remains extant provided the manufacturer, where applicable, complies with the requirements of MQT within the respective standard.

## 1.2. Rationale

Since the 2007 standard, the Home Office Centre for Applied Science and Technology (CAST) has engaged with a range of stakeholders to establish a set of operational requirements for the Home Office Body Armour Standard (2017). These included the National Police Chiefs Council (NPCC), the Police Federation, end-users, manufacturers of body armour, test facilities and technical experts.

These requirements provided direction for a body of work to produce a test standard that better represented the needs of end-users. The key requirement for body armour is to reduce the risk of death or serious injury to the wearer from ballistic or stab attack to the torso in normal operational usage.

Key differences from the *HOSDB Body Armour Standards for UK Police 2007* include:

- **Formed armour testing:** anthropometrically derived test surrogates, more representative of the morphologies of the female torso enabling enhanced assessment of female body armour.
- **Ballistic protection levels:** an updated set of ballistic protection levels with test rounds reflecting the current operational requirements of UK law enforcement.
- **Rifle testing:** anthropometrically derived male front and back torso surrogates for ballistic testing to provide enhanced assessment on the performance of rifle protection.
- **Production quality testing (PQT):** introduction of critical perforation analysis (CPA) as a quality assurance tool to provide increased confidence in the continued production quality of soft armour.
- **In-life monitoring (ILM):** periodical assessment of in-service body armour over a period of time to ensure performance is maintained.

### 1.3. Guidance

A supplementary guidance document is also available, *Home Office Body Armour Standard (2017) – Guidance (Publication No. 039/17)*, providing additional information on the intended use of the standard. This document has been written to be used alongside the standard and provides information to enable informed decision making in the selection and procurement of body armour and inform elements of best practice associated with its use.

## 2. Scope

### 2.1. Inclusions

This standard has been written to address the operational requirements of UK law enforcement when faced with ballistic threats from firearms, edged (knife) and non-edged (spike) weapons. The primary region of consideration in this standard is the torso, addressing frontal and rear impacts. Auxiliary to this, protection for areas of extended coverage (e.g. shoulder, neck) interfacing with the body armour in the torso region has also been included.

Within this standard, to ensure continued performance in the production of the body armour, periodic PQT has been included. Similarly, to ensure continued performance of in-use operational armours, periodic ILM of armour has been included.

Body armour certified to this standard is deemed to be ballistic and/or stab resistant only. Certification to this standard ensures that the armour meets the minimum performance requirements only. It is the responsibility of the end-user to ensure that the body armour addresses their particular requirements. It is the responsibility of the manufacturer to ensure the continued quality of their product.

### 2.2. Exclusions

Elements not directly addressed by this standard include protection against:

- **Slash:** attacks characterised by a short duration swipe of a bladed weapon across the body.
- **Fragmentation:** characterised by small high velocity projectiles, often generated as a product of an explosive event.
- **Blunt trauma:** characterised by relatively low velocity, high mass impacts with a blunt interface (e.g. thrown objects, road traffic accidents).

Although the body armour produced in compliance with this standard has not been designed to address the above impact types, it may indirectly provide a level of protection. Other Home Office standards directly address the requirements for blunt trauma and slash resistant protective clothing:

*HOSDB Slash Resistance Standard for UK Police (45/05) (2006)*

*HOSDB Blunt Trauma Protector Standard for UK Police (20/07) (2007)*

## 3. Manufacturers information

### 3.1. General information

This section details the requisite procedures for the certification of body armour intended for law enforcement.

Certification only applies to a particular model of armour, manufactured in accordance with the manufacturer's technical file. No changes to the construction are permitted under this certification without prior notification to CAST. CAST shall assess changes on a case-by-case basis and these may be subject to further testing, in accordance with the methods documented within this standard. Any armour which fails in certification cannot be re-submitted using the same construction.

Each body armour produced post certification shall have a unique serial number identifying the individual armour. Manufacturers are responsible for ensuring continued performance of their armour, via their quality assurance process. In addition, manufacturers shall adhere to the PQT and, where applicable, ILM procedures outlined within this standard.

CAST reserve the right to spot check armour at any time should it be considered necessary.

If there are significant concerns relating to the safety or quality of any armour, CAST reserves the right to withhold or remove certification.

All certification testing must be performed at one of CAST's accredited test facilities (Appendix C). Manufacturers may witness testing of their own products at accredited test facilities, subject to agreement with the facility, but are prohibited from interfering with test protocol.

Details of certified products will be shared on a public database. The following information will be published (if a manufacturer does not wish for their product to be included on the database this shall be made clear during the submission process).

- Manufacturer name.
- Armour model unique identifier (model reference).
- Protection level(s).
- Certification expiry date (date after which, the armour certification is no longer valid and requires a PQT certificate).
- PQT test reference (once minimum test criteria met).

### 3.2. Armour classifications

#### 3.2.1. Protection levels

There are three main categories of protection within the standard: ballistic, knife, and knife with spike. Body armour submitted for certification testing can be assessed to multiple protection

levels within and between protection categories. For example, a single body armour could be tested for multiple ballistic protection levels as well as knife and spike protection.

### 3.2.2. Types of armour

For the purposes of this standard, body armour has been classified into the following groups.

**Unformed armour:** Flat protective panels, typically designed for male end-users. If these unformed panels are intended for female wearers, they shall be tested in accordance with formed armour test methods outlined in Sections 6.6 and Section 7.8.

**Formed armour:** Protective panels which are not flat and shaped to conform to the wearer, of particular relevance in female armour.

Formed armour submitted for testing must have equivalent unformed armour of the same construction, tested in accordance with the unformed ballistic (Section 6.5.) and stab methods (Section 7.7), as applicable. If there is no equivalent certified unformed armour, this can be achieved:

- if the formed front panel is of exactly the same material lay-up and construction (excluding any methods used for shaping<sup>2</sup>) as the unformed armour model, it shall be associated with a rear panel of that model;
- if the formed front panel is a soft armour and of a unique construction, unformed armour panels shall be purpose made and supplied to enable certification testing of the construction to be completed. Such panels shall be of equivalent sizing to the formed armour submitted for testing. The unformed panels assessed in this instance are referred to as 'associated' panels.

When certified, a formed front panel may be supplied with any rear panel from the same manufacturer that is of the same protection level(s).

**Plates:** Hard armour designed to protect against specific test rounds, typically rifle and shotgun. Either considered standalone or in conjunction with a specified (formed or unformed) certified backing armour.

**Extended coverage panels:** Additional panels designed to offer protection outside of the main torso region. For example, shoulder, groin or neck guards.

Extended coverage panels shall either be of the same construction as certified unformed armour or the manufacturer shall supply associated unformed panels of the same construction for assessment in accordance with unformed ballistic (Section 6.5) and stab methods (Section 7.7), as applicable.

If extended coverage panels do not meet minimum performance requirements, this does not affect the equivalent certified unformed armour.

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<sup>2</sup> No additional material shall be added.

### 3.2.3. Scalable solutions

Scalable solutions refer to the combination of more than one protective panel to achieve an enhanced level of protection. This is permissible within the standard, provided that the scalable solution is:

- assessed as individual panels prior to combining;
- assessed together in all certification tests;
- sold in the configuration tested with explicit guidance for the user on its composite construction and wear instructions;
- re-submitted for certification when any modification is made to the certified scalable solution.

## 3.3. Sizing, coverage, covers and carriers

### 3.3.1. Sizing

The armour shall be available in a range of sizes to ensure a close fit to the user's body and allow for variation in size and build of the end-user population. It shall also be adjustable to ensure fit against body and accommodate a modest variation in the size of the end-user.

Feathering at the sides of the protective panels may be adopted to enhance the comfort of the body armour.

### 3.3.2. Coverage

Body armour should provide protection to the vital organs. A formal coverage assessment is not included in this standard; however, this should be addressed as part of any police procurement. Guidelines on coverage requirements are presented in the *2017 Home Office Body Armour Standard (2017) – Guidance* (Publication No. 039/17).

CAST reserves the right to evaluate and review certification of any armour based on its coverage against these guidelines.

### 3.3.3. Armour covers

Covers enclosing the protective panels shall be waterproof to a hydrostatic head of 5,000 mm in accordance with ISO 811:1981 and fully sealed unless the manufacturer can provide evidence to CAST that adequately demonstrates the protective materials are not affected by moisture.<sup>3</sup>

Where the body armour contains plates with affixed protective elements or backing materials, these shall be securely adhered to the plate such that they could not be inconspicuously removed.

The armour covers provided for certification shall be identical to those sold. If, post certification, a manufacturer wishes to add any additional covers to the panels, they shall inform CAST. Such covers shall conform to the labelling requirements of Section 3.4. Any subsequent batch or PQT shall be performed without this additional cover.

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<sup>3</sup> This evidence is not the same as the optional pre-conditioning wet testing specified in certification.

### 3.3.4. Armour carriers

If the protective panels are to be inserted into a carrier, it may be of overt or covert design. The design of the carrier may differ according to the requirements of the end-user; however, it shall ensure that the panels are held securely against the body over the intended part of the torso. Where possible, the protective panels should be removable from the armour carrier to permit laundering.

Assessment of the operational armour carrier is not always required as part of certification testing. Where a carrier is required for testing (e.g. plates in conjunction with unformed armour), it shall be specified explicitly in the relevant sections. In these instances, protective panels submitted for testing shall be provided in a plain, single-layer armour carrier of areal density not exceeding 220 g.m<sup>-2</sup>.

All zips on the armour carrier shall be covered to reduce the risk of fragmentation injury from bullet impacts.

CAST reserve the right to specify additional assessments of the operational carrier if deemed necessary.

## 3.4. Labelling

### 3.4.1. General requirements

A label shall be securely fixed to the body side of each protective panel so that it is visible to the wearer. The label shall be at least 75 × 75 mm and include as a minimum:

- manufacturer name;
- date of manufacture;
- batch reference;
- armour model unique identifier (model reference);
- unique item identifier (serial number);
- protection level (e.g. HO1 + KR1);
- front or back panel identifier;
- identification of 'body side' using the following text, with text height of at least 10 mm: 'THIS SIDE TO THE BODY';<sup>4</sup>
- colour-coded labels to identify protection type (see Figure 1);
- care and maintenance instructions;
- for certification test panels, a separate label shall be used with the following statement clearly visible: 'THIS IS A TEST PANEL ONLY, DO NOT WEAR';
- for certified panels, the test house reference shall be shown;<sup>5</sup>
- if panels have been pre-conditioned in accordance with Section 9.2, the label shall clearly state either 'Wet Tested' or 'Extreme Temperature Tested';
- if the panels have been tested with additional test rounds, these shall be clearly stated on the label.

Unless otherwise specified, text on the label shall have a minimum height of 3 mm.

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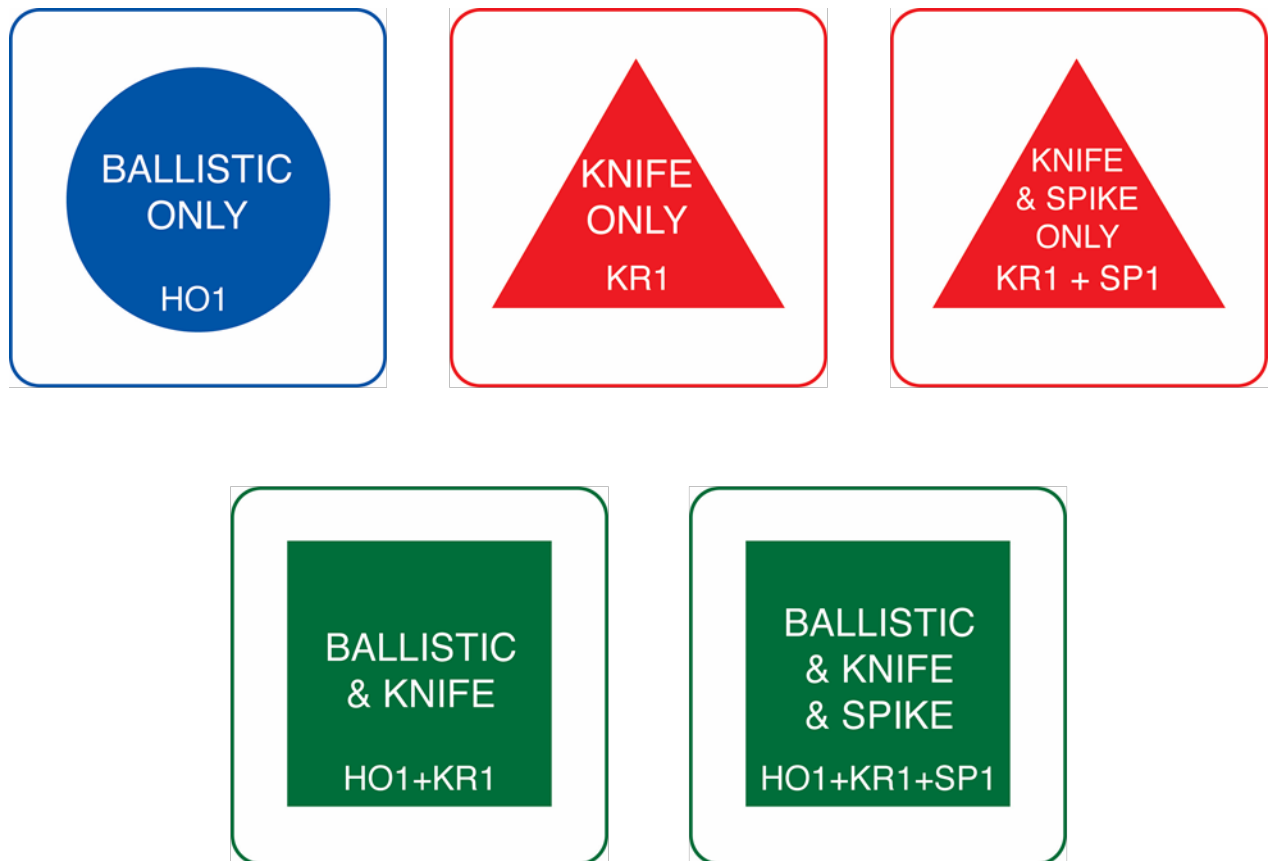
<sup>4</sup> This may be affixed to the panel as an additional label if necessary.

<sup>5</sup> This shall include original certification reference plus the most recent PQT reference (where applicable).



For extended coverage panels, where there is a tapering in panel geometry defined based on the criteria outlined in Section 6.10.2. The manufacturer may choose to identify an area of full protection; this area shall be marked with the text 'AREA OF FULL PROTECTION' on the strike face of the panel.

On scalable solutions, where multiple protective panels are used in combination, labels adhering to the specified requirements shall be provided on the body side of each panel. The label shall clearly detail the protection levels of the individual panels and the protection level of the resultant combination of panels. Further instruction shall be explicitly displayed on the labels outlining the order in which panels must be worn, with features added to prevent incorrect orders (e.g. physical fastening).



**Figure 1: Examples of colour-coded labels to be affixed to protective panels – blue circle for ballistic protection, red triangle for stab protection, green square for ballistic and knife and ballistic, knife and spike protection**

### 3.4.2. Labelling assessment

The label should be fully readable to anyone with normal or corrected vision throughout its product life expectancy (plus two years). Manufacturers should assess the longevity of labels prior to production.

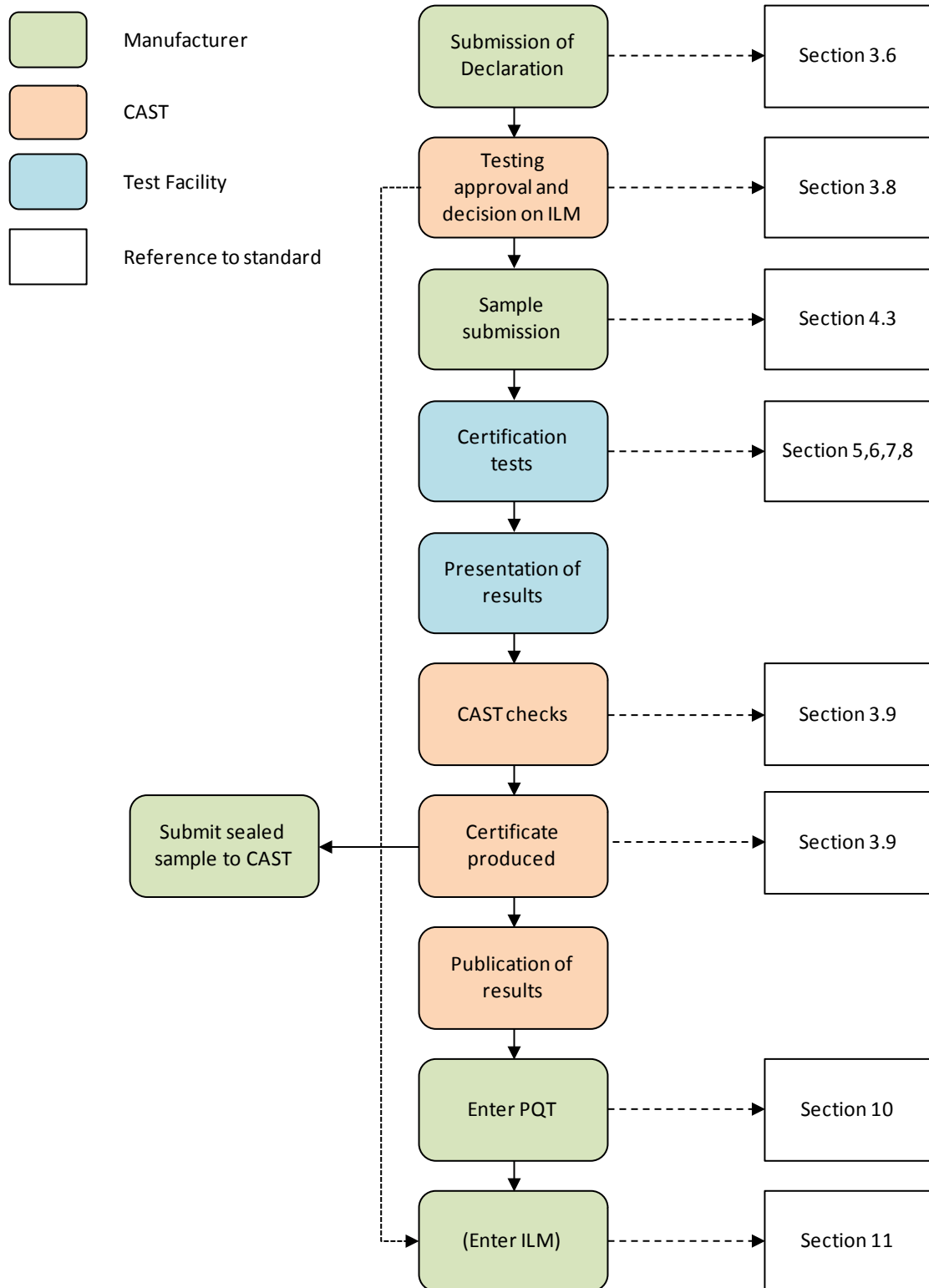
If labels degrade and become unreadable in service, they shall be replaced immediately at the cost of the manufacturer.

It is the responsibility of the end-user to ensure the product continues to meet these requirements.

### 3.5. Certification process

Figure 2 outlines the key elements involved in the submission of armour for testing in order to achieve certification to this standard.

Any testing completed outside of this process will be considered as development testing only and results will not be accepted as part of the certification process.



**Figure 2: Process map for certification to the 2017 Home Office Body Armour Standard**

## 3.6. Declaration of construction

For each model of armour, a completed declaration of construction (Appendix A), shall be submitted via email to [declarations@homeoffice.gsi.gov.uk](mailto:declarations@homeoffice.gsi.gov.uk). This shall be supported by both a comprehensive technical file and redacted technical file. The subject of the email shall follow the naming convention: [*Manufacturer*] – [*Armour Model Unique Identifier*] – [*Protection Level*] – [*Chosen Test Facility*].<sup>6</sup>

### 3.6.1. Technical file

The technical file shall be submitted in a PDF file format on company headed paper and detail the following information as a minimum:

- Company details:
  - name;
  - postal address;
  - named point of contact including telephone number and email address;
  - proof of accreditation to a recognised quality standard (e.g. ISO 9001).
- Details of any subcontractors used:
  - company details (as above);
  - proof of accreditation to a recognised quality assurance standard (e.g. ISO 9001);
  - details of process or products supplied;
  - full technical file for products supplied.<sup>7</sup>
- Armour model unique identifier (model reference).
- Protection level(s).
- Panel construction material lay-up (from strike face to body side).
- Carrier designs (examples).
- Full details of all materials used within the construction:
  - material manufacturer company details (as above);
  - location of manufacturing facility for material;
  - material data sheets – details in Appendix B.
- Technical drawings of armour design (including both formed and unformed as applicable):
  - complete details of the size roll anticipated by manufacturer at point of certification (full size roll) including scale drawings with key dimensions and areal coverage.
  - detail of any feathering (if applicable).
- Labelling templates and example (Section 3.4):
  - wording;
  - fixing methods;
  - fixing location.
- Product life expectancy – specified duration over which armour materials are known to provide the protection level it is being tested for and evidence to support this. Acceptable evidence must include destructive testing on the particular combination of

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<sup>6</sup> It is the responsibility of the manufacturer, prior to submission of the technical file, to arrange testing with one of CAST's approved test facilities (Appendix C).

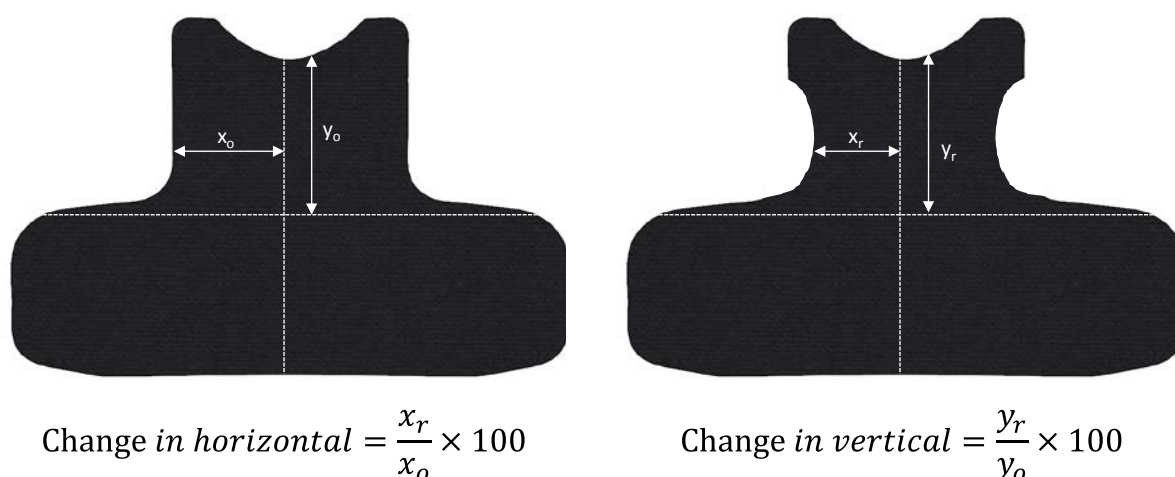
<sup>7</sup> May be supplied directly to CAST from sub-contractor if required.

materials in the armour construction evaluated over at least the period of time specified in the product life expectancy.<sup>8</sup>

- Internal batch testing regime – details of internal test methods (both non-destructive and destructive) and frequency of testing.

### 3.6.2. Changes in panel size/design

If, during production, the manufacturer is required to manufacture a size of protective panel with an areal coverage more than 5% outside of the range specified in the technical file, CAST should be contacted for advice. Any change in design where a measurement is moved closer to either the vertical or horizontal centrelines in the armour by more than 15% of its original distance, CAST should be contacted for advice. Figure 3 illustrates an example of the measurements required to identify a change in design.



$x_o$  – original horizontal measurement;  $y_o$  – original vertical measurement;  $x_r$  – revised horizontal measurement;  $y_r$  – revised vertical measurement

**Figure 3: Armour with centrelines and measurements marked for design consideration**

### 3.6.3. Redacted technical file

A redacted technical file shall also be provided to CAST for review at the declaration stage to enable test facility pre-test assessments and construction checks.<sup>9</sup> This redacted technical file shall contain:

- drawings of panels submitted (including feathering and areal coverage);
- type of material (e.g. woven, laminated);
- number of layers;
- quilting and construction details (e.g. stitching pattern).

All technical files will be protectively marked as ‘OFFICIAL SENSITIVE [COMMERICAL]’ with handling instructions ‘For use by the Home Office, stated manufacturer and stated test facility only, unless otherwise agreed by all parties’ and kept on record for a minimum of five years.

<sup>8</sup> If such evidence cannot be satisfactorily presented to CAST, the armour shall be subject to ILM (Section 11).

<sup>9</sup> The manufacturer is responsible for ensuring any confidentiality agreement with their selected test facility is in place, as required.

### 3.7. CAST approval to test

Once the declaration and associated technical files have been submitted, CAST will review and decide whether the submission meets the requirements for certification testing. On acceptance, CAST will authorise the selected CAST accredited test facility to initiate the certification testing process.<sup>10</sup>

In exceptional circumstances CAST may provisionally accept the armour for testing prior to full acceptance of the technical file and declaration. If this is required by the manufacturer, a full justification explaining why it is necessary shall be provided to CAST for consideration. Certification will not be completed until all documentation is accepted by CAST.

### 3.8. Sample submission

On approval of the declaration, the manufacturer shall send armour samples, corresponding to the requirements of Section 4.3 for testing to their chosen CAST accredited test facility. It is the manufacturer's responsibility to ensure that the appropriate quantity of test samples are provided to the CAST accredited test facility for testing to the protection level(s) specified. These samples shall be accompanied with a redacted technical file (Section 3.6.3). It is the responsibility of the manufacturer to ensure appropriate export licences are sought and export protocol is followed in the submission of armour and information to test facilities.

### 3.9. CAST checks and certification

On receipt of test reports from the accredited test facility, CAST will independently review them. If successful, CAST will then issue the manufacturer with a certificate detailing the outcomes of the test and pertinent information on the performance of armour. This shall include:

- manufacturer's name;
- manufacturer's address;
- armour type (unformed armour, formed armour, plate or extended coverage panel);
- protection level(s);
- accredited size range (smallest to largest);<sup>11</sup>
- available as (form in which armour supplied);
- areal density;
- performance metrics (ballistic:  $V_{50}$ , mean BFS; stab: mean depth of penetration);
- additional testing (wet/extreme temperature);
- product life expectancy;
- in-life monitoring;
- original test house reference;
- current PQT test reference;
- current ILM test reference;
- issue date;
- expiry date.

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<sup>10</sup> Any testing conducted prior to receipt of CAST authorisation will be considered as development testing only and will not form part of the certification testing process.

<sup>11</sup> For formed armour, this shall be given by the size range of the equivalent unformed armour.

On certification, manufacturers shall send a sealed medium sample of the certified armour to CAST for audit purposes.

## 3.10. Post certification

### 3.10.1. Production quality testing

Once an armour model has been certified, it is automatically subject to the PQT protocol. Independent assessments are specified at a series of intervals to ensure the performance of armour during production remains at the certified levels. Details of the threshold frequencies for PQT and test methods are documented in Section 10.

### 3.10.2. In-life monitoring

In instances where the manufacturer is unable to provide sufficient information to support their specified product life expectancy, armour models will be subject to the ILM protocol. In this scheme, in-service armour will be retrieved from end-users every two years for testing to provide greater confidence in its continued performance in the field.

Manufacturers may also wish to opt in to this scheme, which shall be indicated to CAST on submission of the declaration. Details on the ILM protocol are documented in Section 11.

## 4. Summary of tests

### 4.1. Certification testing

A summary of the certification tests within this standard have been given in Table 1.

**Table 1: Summary of assessments for certification testing**

Section	
3.4	<b>Labelling</b> Visual inspection of labelling ensuring required information is presented and it is of appropriate quality.
<b>Pre-testing</b>	
5	<b>Pre-testing assessments</b> Inspections and areal density measurements on submitted body armour, against the redacted technical file, prior to testing.
<b>Ballistic testing</b>	
6.5	<b>Soft, unformed</b> Assessment of unformed (i.e. flat) body armour against a flat Roma Plastilina® No. 1 tray backing.
6.6	<b>Soft, formed</b> Assessment of formed body armour (e.g. armours intended for females) against a Plastiline® 40 torso-shaped backing.
6.7	<b>Plates</b> Assessment of plates, either standalone or in conjunction with a certified soft armour protective panel, against a Roma Plastilina® No. 1 torso-shaped backing. If intended for female users (standalone or in conjunction with certified formed or unformed armour), an assessment shall be conducted on large female Plastiline® 40 torso-shaped backing. Any such armour shall have an equivalent certified plate tested on the Roma Plastilina® No. 1 male torso-shaped backing.
6.8	<b>Critical perforation analysis (CPA)</b> Conducted only after successful completion of other ballistic testing, CPA is an assessment of the velocity associated to a given statistical probability of body armour perforation. This test determines the velocity at which 1% of shots are predicted to perforate the armour being tested, $V_{01}$ , as well as the velocity at which 50% of shots are predicted to perforate the armour being tested, $V_{50}$ .

Section	
6.10	<p><b>Extended coverage (optional)</b></p> <p>Assessment of extended coverage panels such as groin, shoulder or neck protectors against Roma Plastilina® No. 1 backing. Note that extended coverage panels that fail to meet the requirement do not affect the certification of the torso panels of the same construction.</p>
<b>Knife/spike testing</b>	
7.7	<p><b>Soft, unformed</b></p> <p>Assessment of unformed body armour on flat composite foam-based backing materials in a guided-mass, gravity-driven drop test system against knife and/or spike end-effectors.</p>
7.8	<p><b>Soft, formed</b></p> <p>Assessment of formed body armour on a Plastiline® 40 shaped backing in a guided-mass, gravity-driven drop test system against knife and/or spike end-effectors.</p>
7.10	<p><b>Extended coverage (optional)</b></p> <p>Assessment of extended coverage panels on flat composite foam-based backing materials in a guided-mass, gravity-driven drop test system against knife and/or spike end-effectors. Note that extended coverage panels that fail to meet the requirement do not affect the certification of torso panels of the same construction.</p>
<b>Post-testing</b>	
8	<p><b>Construction assessments</b></p> <p>Inspection of all tested protective panels to ensure they have been manufactured in accordance with the manufacturer's declaration of construction and technical file.</p>

## 4.2. Post-certification testing

A summary of the post-certification tests within this standard have been given in Table 2.

**Table 2: Summary of assessments for post-certification testing**

Section	
9.2.1	<p><b>Wet testing (optional)</b></p> <p>To simulate body armour being immersed in water prior to being worn, this assessment preconditions the certified individual protective panel in water before ballistic and/or stab testing.</p>
9.2.2	<p><b>Extreme temperature testing (optional)</b></p> <p>To simulate body armour being stored in extreme temperatures prior to being worn, this assessment preconditions certified individual protective panels at either +50°C or -20°C and allows them to return to standard temperature prior to ballistic and/or stab testing.</p>



Section	
10	<p><b><i>Production quality testing (PQT)</i></b></p> <p>In ballistic testing, CPA shall be performed on soft unformed armour. Soft, formed armour and plates shall be tested in the same manner as in certification testing but with fewer panels required.</p> <p>Similarly, stab testing shall be conducted in the same manner as certification but at reduced quantities compared to certification testing.</p>
11	<p><b><i>In-life monitoring (ILM)</i></b></p> <p>To ensure armour exhibits consistent performance for the duration of the product life expectancy (as specified by the manufacturer), in-service panels shall be acquired and tested.</p>

### 4.3. Submission requirements

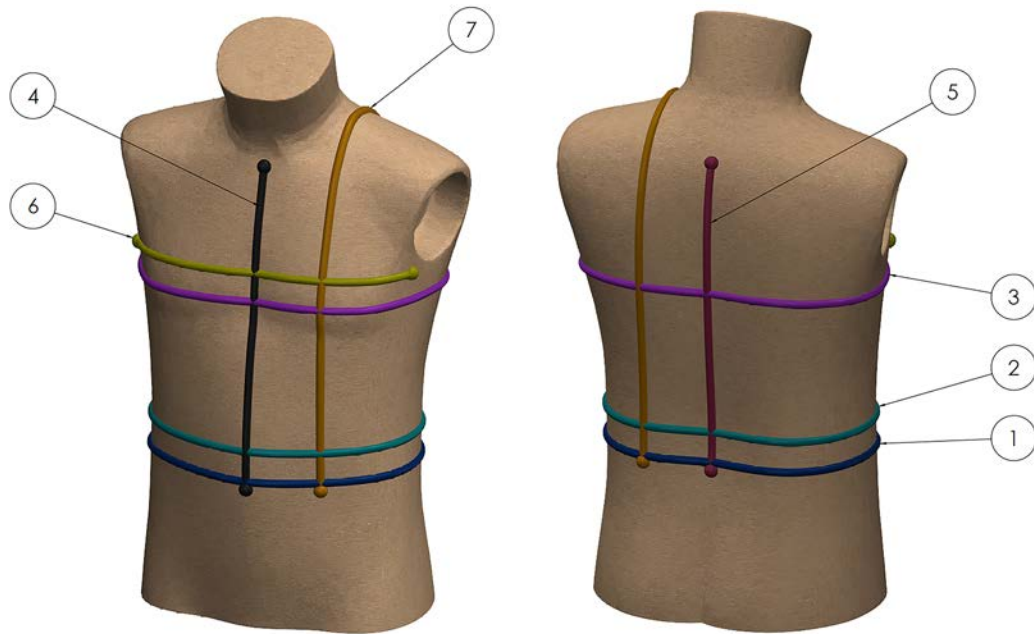
#### 4.3.1. Size selection

##### 4.3.1.1. Unformed armour

Three armour sizes are required for certification testing: small, medium and large. Small shall be the smallest panel that the manufacturer intends to supply. Large shall be the largest panel that the manufacturer intends to supply. Medium shall be sized to fit the dimensioned torso mannequin, shown in Figure 4. Key dimensions are provided in Table 3. The range of sizes specified and tested shall be included as the accredited range on the certificate.

If, at a later stage, the manufacturer is required to produce armour that is outside of the range defined in the technical file and the changes are not covered by the criteria in Section 3.6.2, they shall inform CAST and provide full details of the new panel size. It may be necessary to complete additional testing on these panels.

All assessments on unformed armour shall be conducted without carriers.



**Figure 4: Dimensioned medium male torso**

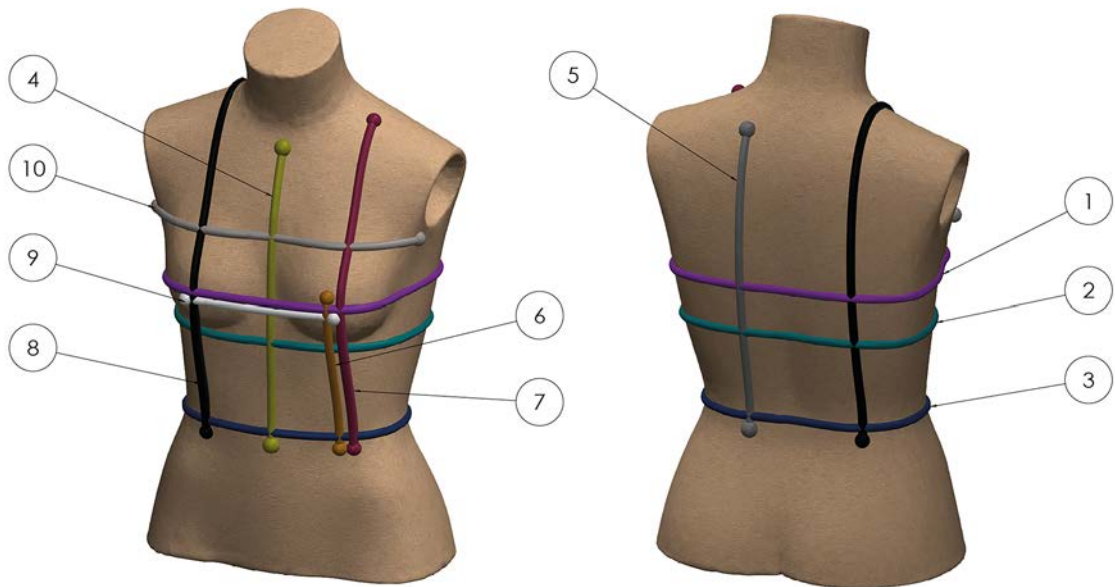
**Table 3: Male torso dimensions**

No.	Colour	Measurement	Description	Dimension (mm)
1	Blue	Waist circumference	Measured at top of waist.	940
2	Teal	Stomach circumference	Measured at the most pronounced region of the stomach.	955
3	Purple	Chest circumference	Measured at the most pronounced region of the chest.	1,040
4	Black	Front torso length	Measured front the jugular notch to the top of the waist.	390
5	Maroon	Rear torso length	Measured from the 7 <sup>th</sup> vertebrae to the top of the waist.	450
6	Green	Width between arms	Span across chest, measured from deepest point of arm pits.	510
7	Orange	Waist-to-waist (front to rear)	Measured distance from the front waist over the highest part of the shoulder to the rear waist.	980

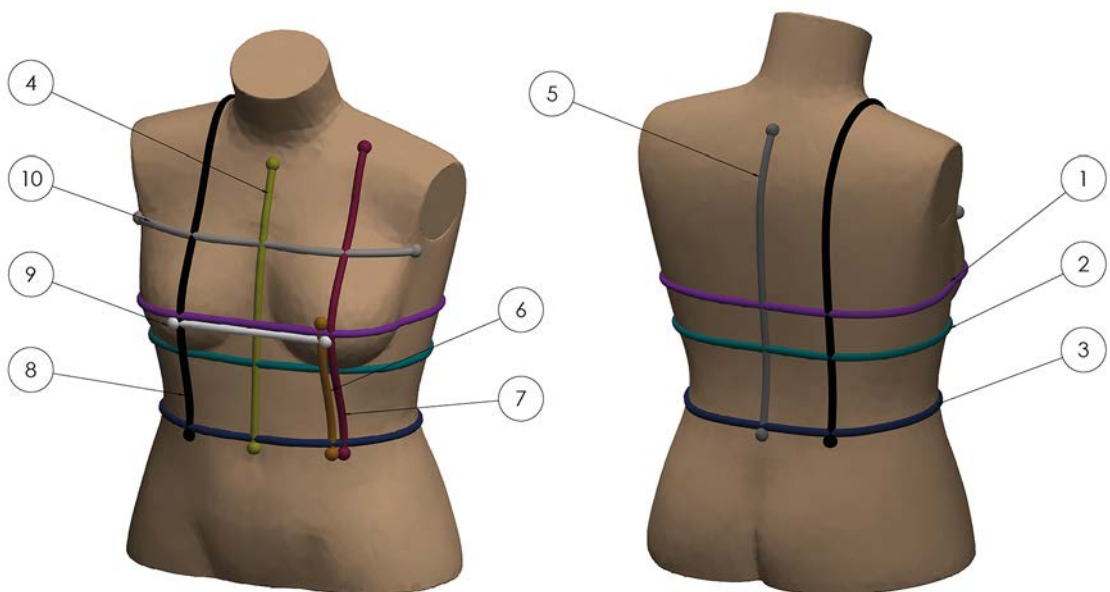
### 4.3.1.2. Formed armour

Formed armour required for certification shall be supplied in two sizes based on the female mannequins in Figure 5 and Figure 6. Key dimensions are provided in Table 4.

All assessments on formed armour shall be conducted in carriers following the requirements outlined in Section 3.3.4.



**Figure 5: Dimensioned small female torso**



**Figure 6: Dimensioned large female torso**

**Table 4: Female torso dimensions**

No.	Colour	Measurement	Description	Dimension (mm)	
				Small female torso	Large female torso
1	Purple	Bust circumference	Measured at the most pronounced region of the bust.	910	1,040
2	Teal	Below bust circumference	Measured just beneath the bust.	785	930
3	Blue	Waist circumference	Measured at top of waist.	695	920
4	Green	Front torso length	Measured from the jugular notch to the top of the waist.	345	360
5	Grey	Rear torso length	Measured from the seventh vertebrae to the top of the waist.	400	440
6	Orange	Bust height	Measured from the top of waist to the most pronounced region of the bust.	180	190
7	Maroon	Front shoulder height	Top of waist to highest point of the shoulder (over bust).	430	460
8	Black	Waist-to-waist (front to rear)	Measured distance from the front waist over the highest part of the shoulder to the rear waist.	890	930
9	White	Bust width	Span between most pronounced regions of each bust.	175	205
10	Beige	Width between arms	Span across chest, measured from deepest point of arm pits.	435	470

#### 4.3.1.3. Plates

Plates (standalone or in conjunction with certified unformed armour) submitted for certification shall be supplied to fit the male torso mannequin specified in Table 3.

If plates are intended for female end-users (standalone or in conjunction with certified formed or unformed armour) they shall be sized to fit the female large front mannequin. Note any plates shaped for female users must have an equivalent plate, of the same construction, tested on Roma Plastilina<sup>®</sup> No. 1 shaped backing in accordance with the methods outlined in Section 6.7. If there is not already an equivalent certified plate, purpose-made plates shall be submitted in accordance the quantity requirements in Section 0 and the test methods outlined in Section 6.7.

All assessments on plates shall be conducted in carriers following the requirements outlined in Section 3.3.4.

#### 4.3.1.4. Extended coverage panels

Two sizes of extended coverage panel are required for certification of each design of panel, small and large. Small shall be the smallest panel that the manufacturer intends to supply. Large shall be the largest panel that the manufacturer intends to supply. The range of sizes specified and tested shall be included as the accredited range on the certificate.

If the extended coverage panels are made from soft armour constructions, they shall have an equivalent certified unformed armour. Hard extended coverage panels (plates) shall have an equivalent certified full-sized plate.

#### 4.3.2. Quantities of armour required

Table 5 and Table 6 show the number of panels required for each protection level for certification testing in accordance with the requirements of Sections 6 and 7.

For ballistic testing to HO3, HO4 and SG1 protection levels, plates may be assessed as standalone products or in conjunction with previously certified HO1 or HO2 panels which have been assessed and certified accordingly.

Refer to Section 10 for PQT.

**Table 5: Quantities of armour required for ballistic test certification**

Protection level	Panel type	Ballistic						Additional 'special' ballistic (for additional threat ammunition – per test)						CPA (minimum quantity – large panels)
		Small		Medium		Large		Small		Medium		Large		
		F	B	F	B	F	B	F	B	F	B	F	B	
HO1 or HO2	Unformed	2	2	3	3	1	1	1	1	2	1	1		3
	Formed <sup>12</sup>	4				4		2				2		
HO3	Plate* <sup>13</sup>			2	2					1	1			
HO4	Plate*			3	3					1	1			
SG1	Plate*			1	1									
<b>Extended coverage**</b>		1				1		1					1	

F = front panel; B = back panel; dark grey boxes – no panels required.

<sup>12</sup> All formed armour submitted for testing shall be sized in accordance with specifications in Section 0.

<sup>13</sup> All plates submitted for testing shall be sized in accordance with specifications in Section 4.3.1.3.

\* If intended for female end-users (standalone or in conjunction with certified soft armour), an additional two plates are required, sized to fit the female large torso mannequin.

\*\* A single small and large extended coverage panel is required per ammunition type at each protection level.

**Table 6: Quantities of armour required for knife/spike test certification**

Protection level	Panel type	Size (all front)		
		Small	Medium	Large
KR1 or KR2	Unformed	1	1	1
	Formed	1		1
	Extended coverage	1		1
KR1 + SP1 or KR2 + SP2	Unformed	2	1	2
	Formed	2		2
	Extended coverage	2		2

## 5. Pre-testing assessments

### 5.1. General information

On submission of samples for testing, test facilities shall be supplied with a redacted technical file from the manufacturer containing the details specified in Section 3.6.3. This technical file shall be used in assessments to enable comparisons with the supplied armour.

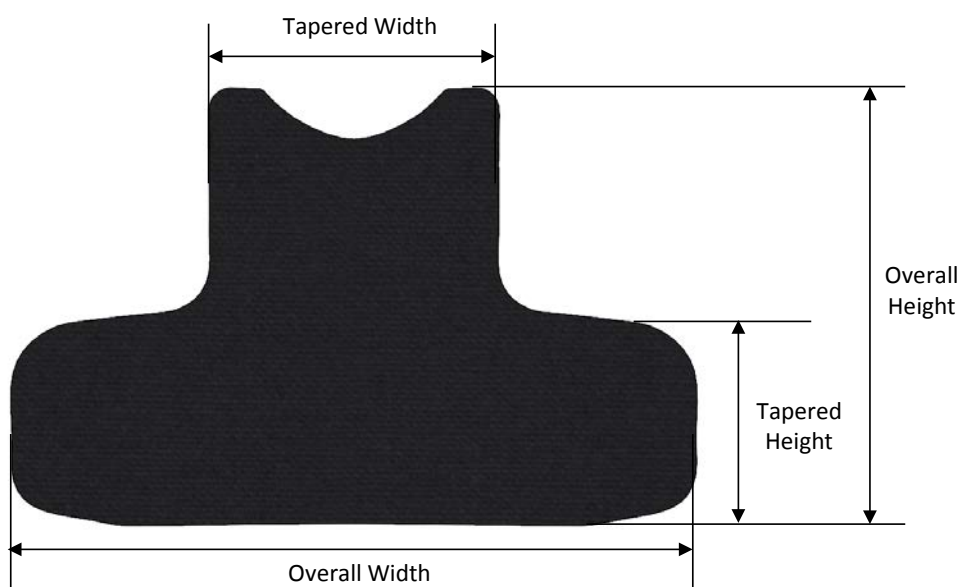
### 5.2. Summary of assessments

#### 5.2.1. Inspection

Initially, on receipt of armour from the manufacturer, a visual inspection shall be performed to assess general quality of construction. Defects such as damage, blisters, cracks, tears, fraying and stitching separation shall be recorded.

#### 5.2.2. Areal density

Prior to testing, all submitted protective panels shall be weighed outside of their carriers on a calibrated set of scales, accurate to 0.1 g. The size of each panel, excluding armour covers, shall then be checked against dimensioned drawings provided by the manufacturer. This shall include, as a minimum, the overall width (largest separation in horizontal axis), overall height (largest separation in vertical axis), height and width of tapered regions, as shown in Figure 7.



**Figure 7: Dimensional measurements on submitted armour**

On these drawings the manufacturer shall provide confirmation of the surface area of each panel construction submitted. The mass of the protective panels and associated areas shall then be used with the stated area to calculate areal density.

Should there be a deviation between the drawings provided by the manufacturer and the dimensions measured of greater than 5% in any single measurement, the area of the panel shall be calculated manually by tracing around the perimeter of the armour using Polyart™ paper (140 g.m<sup>-2</sup>, 0.175 mm thickness).<sup>14</sup> This paper shall then be weighed and used to calculate areal density using Equation (3).

$$\text{Areal Density (kg.m}^{-2}\text{)} = \left( \frac{\text{mass of armour (kg)}}{\text{mass of paper (kg)}} \right) \times \text{areal density of paper (kg.m}^{-2}\text{)} \quad (3)$$

Such discrepancies shall be recorded and reported to CAST.

### 5.3. Reporting

Inspection notes and areal densities shall be recorded in the template provided by CAST<sup>15</sup> along with any associated relevant information (e.g. photographs). This spreadsheet shall be submitted with test reports on completion of testing.

All test reports will be protectively marked as 'OFFICIAL SENSITIVE [COMMERICAL]' with handling instructions 'for use by the Home Office, stated manufacturer and stated test facility only, unless otherwise agreed by all parties and kept on record for a minimum of five years'.

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<sup>14</sup> The areal density of the paper shall be measured prior to calculation.

<sup>15</sup> Available on request to CAST.



# 6. Ballistic testing

## 6.1. General ballistic testing requirements

### 6.1.1. Performance assessment criteria

All ballistic armour, regardless of protection level, shall satisfy the following requirements. Following a fair strike:

- no bullet shall completely pass through (perforate) the protective panel;
- no part of the bullet shall be visible from the body side of the protective panel;<sup>16</sup>
- no bullet or part of the bullet shall exit from the sides of the protective panel;
- no spall or fragments of hard armour (e.g. ceramic plate, pieces of metal) shall enter the backing material;
- the BFS measurements shall not exceed the limits specified according to the protection level being assessed (see Table 8).

### 6.1.2. Fair strike

A fair strike shall be recorded if:

- the shot velocity is within the specified range;
- shot placement rules are adhered to;
- unless otherwise specified, the shot is perpendicular to the target.<sup>17</sup>

In any fair series of strikes, the mean of all velocities in a certification test series at a given protection level shall equal or exceed the specified velocity (e.g. for an armour submitted for HO1 testing, the mean of all shots must be 365 m.s<sup>-1</sup> or greater).

### 6.1.3. Exceptions

The following conditions represent exceptions to the fair strike criteria for ballistic testing:

- If the shot velocity is below the specified range but the armour is perforated this shall be classed as a fair strike.
- If the shot velocity is above the specified range, the armour is not perforated and the BFS is within the defined limits; this may be classed as a fair strike upon acceptance by the manufacturer. Beyond this point, any subsequent fair strikes are considered acceptable.
- If the shot placement rules are not adhered to, the armour is not perforated and the BFS is within the defined limits; this may be classed as a fair strike upon acceptance

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<sup>16</sup> Assessed on the last layer (body side) of ballistic material within the panel construction.

<sup>17</sup> It is assumed that the shot is perpendicular if the barrel is perpendicular to the target. If the manufacturer wishes to assess yaw, they may request this to be conducted at their own cost.

by the manufacturer. Beyond this point, any subsequent fair strikes are considered acceptable.

Any strikes that do not meet the fair strike criteria and are not covered by the exceptions shall be recorded as unfair. If an unfair strike is recorded another shot location that complies with the shot placement rules shall be identified by the test facility and an additional shot shall be placed in this location. A maximum of seven shots shall be taken on unformed medium/large protective panels and a maximum of four shots shall be taken on unformed small panels in a test series. No additional strikes may be conducted on formed panels. If there is an unfair strike, an additional formed armour panel shall be provided for testing.

#### 6.1.4. Shot placement rules

Shots shall be placed in accordance with shot patterns defined in Section 6.4.2. In all circumstances the shot placement rules in Table 7 shall be adhered to. The reference point for these distances is the edge of a shot entry hole.

**Table 7: Ballistic shot placement rules**

Panel type	Min. shot-to-shot distance	Min. shot-to-edge distance <sup>18</sup>
Unformed	50 mm	50 mm
Formed	N/A	N/A
Plates	75 mm	50 mm
Extended coverage	N/A	N/A

## 6.2. Protection levels

Ballistic protection levels for certification are given in Table 8.

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<sup>18</sup> Distances specified from shot entry hole to the edge of the armour and/or the edge of the backing material.

**Table 8: Ballistic protection levels**

Protection level	Classification and calibre	Test round designation	Bullet mass	Range (min) (m)	Max. mean BFS (mm)	Single shot BFS limit (mm)	Velocity (m.s <sup>-1</sup> )
HO1	9 mm FMJ	MEN 9 mm FMJ DM11A1B2	8.0 g (124 grain)	5		44.0	365 ± 10
	9 mm JHP	Federal Premium 9 mm JHP P9HST1	8.0 g (124 grain)	5		44.0	365 ± 10
HO2	9mm FMJ	MEN 9 mm FMJ DM11A1B2	8.0 g (124 grain)	5		44.0	430 ± 10
	9 mm JHP	Federal Premium 9 mm JHP P9HST1	8.0 g (124 grain)	5		44.0	430 ± 10
HO3	Rifle 7.62 calibre	Radway Green 7.62 mm NATO Ball L44A1 or L2A2	9.3 g (144 grain)	10	25.0	30.0	830 ± 15
	Rifle 7.62 calibre	7.62 × 39 mm surrogate <sup>19</sup>	7.9 g (122 grain)	10	25.0	30.0	705 ± 15
HO4 <sup>20</sup>	Rifle 7.62 calibre	SAKO .308 Win 480A Powerhead or Barnes .308 TSX BT	10.7 g (165 grain)	10	25.0	30.0	820 ± 15
SG1	Shotgun 12 gauge True Cylinder	Winchester 1 oz. Rifled 12RSE	28.4 g	10	25.0	30.0	435 ± 25
Special	Based on threat and risk assessment						

At each protection level, manufacturers are responsible for the performance of product at all velocities below the specified test ranges.

The mean permissible BFS measurements have been specified in Table 8.

For all protection levels a single shot limit (SSL) has been defined, which gives a maximum BFS limit for a single ballistic shot of a given test round in each protection level for a test series.

<sup>19</sup> 7.62 x 39 mm surrogate round details provided in Appendix D.

<sup>20</sup> Any armour submitted for testing to the HO4 protection level shall also meet the requirements of the HO3 protection level.

If standalone plates (without soft armour) are submitted for assessment, consideration should be given to satisfy the ballistic certification requirements of the HO2 protection level using the rifle shot templates and methods outlined in Section 6.7.

The protection levels listed in Table 8 are defined as minimum protection levels. If, based on the threat and risk assessment, there is a requirement to incorporate additional ammunition this may be done either in addition to any protection level or, for specialist uses, on its own as a 'special' protection level.

Consideration should be given to the requirement to assess any protection level against UK law enforcement ammunition. Due to potential variation in law enforcement ammunition this has not been included in the protection levels. This should be incorporated, as an enhancement, into the relevant protection level for specialist users.

Examples of 'special' test rounds that may be used include, but are not limited to, the rounds specified in Table 9.

**Table 9: Additional 'special' test rounds**

Protection level	Classification and calibre	Test round designation	Bullet mass	Range (min) (m)	Max. mean BFS (mm)	Single shot BFS limit (mm)	Velocity (m.s <sup>-1</sup> )
Special	0.357" Magnum	Soft Point Flat Nose Remington R357M3	10.2 g	5		44.0	390 ± 10 455 ± 10
Special	5.56 × 45 mm SS109	5.56 × 45 mm Ball L17A1 or L15A1	4.01 g (62 grain)	10	25.0	30.0	920 ± 15
Special	Carbine 5.56 × 45 mm NATO	Federal Tactical Bonded 5.56 mm (.223) LE223T3	4.01 g (62 grain)	10	25.0	30.0	750 ± 15

## 6.3. Pre-test conditions

### 6.3.1. Environmental conditions

The firing range shall be maintained at a temperature of 20 ± 3°C. Storage rooms and any associated areas shall be maintained at a temperature of 20 ± 3°C with a 40 to 70% relative humidity. The working temperature and relative humidity of all areas shall be recorded on the test report.

### 6.3.2. Test equipment

#### 6.3.2.1. Calibration and records

All test equipment listed in this section shall be calibrated in accordance with the internal quality management system. Calibration records shall be made available to CAST upon

request. All accredited test facilities shall have equipment approved by CAST. Details of equipment used during each test shall be recorded on the test report.

### 6.3.2.2. Velocity measurement

All velocities shall be measured at a distance of  $2.0 \pm 0.1$  m from the front face of the test panel to the centre of the position of velocity measurement. The velocity of each test shot shall be within the limits specified in Table 8. Velocity shall be recorded in metres per second ( $\text{m}\cdot\text{s}^{-1}$ ) and rounded to the nearest integer value.

The following velocity measurement equipment may be used:

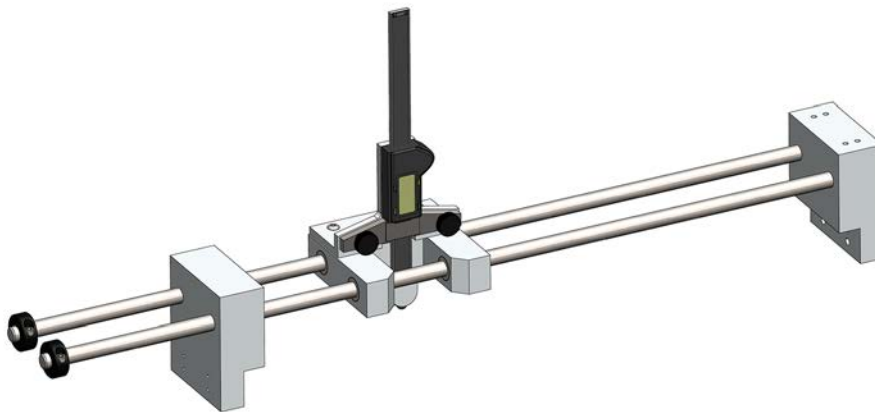
- Doppler radar calibrated with errors no greater than  $\pm 1.0\%$  within the specified test ranges.
- Light gates with minimum sampling rate of 100 kHz and base length of  $1.0 \pm 0.5$  m.

Alternative systems may be used; however, these must first be approved by CAST.

To attain the correct striking distances and velocities detailed in Table 8, static mounted proof barrels, alignment aids and hand loading of the rounds shall be adopted.

### 6.3.2.3. Back face signature measurement

A suitable method of measuring the BFS shall be used. It shall be accurate to  $\pm 0.1$  mm. If using a Vernier calliper, it shall have an 8 mm diameter hemispherical probe. Figure 8 illustrates a suggested tool for such measurement.



**Figure 8: Example of a BFS measurement tool**

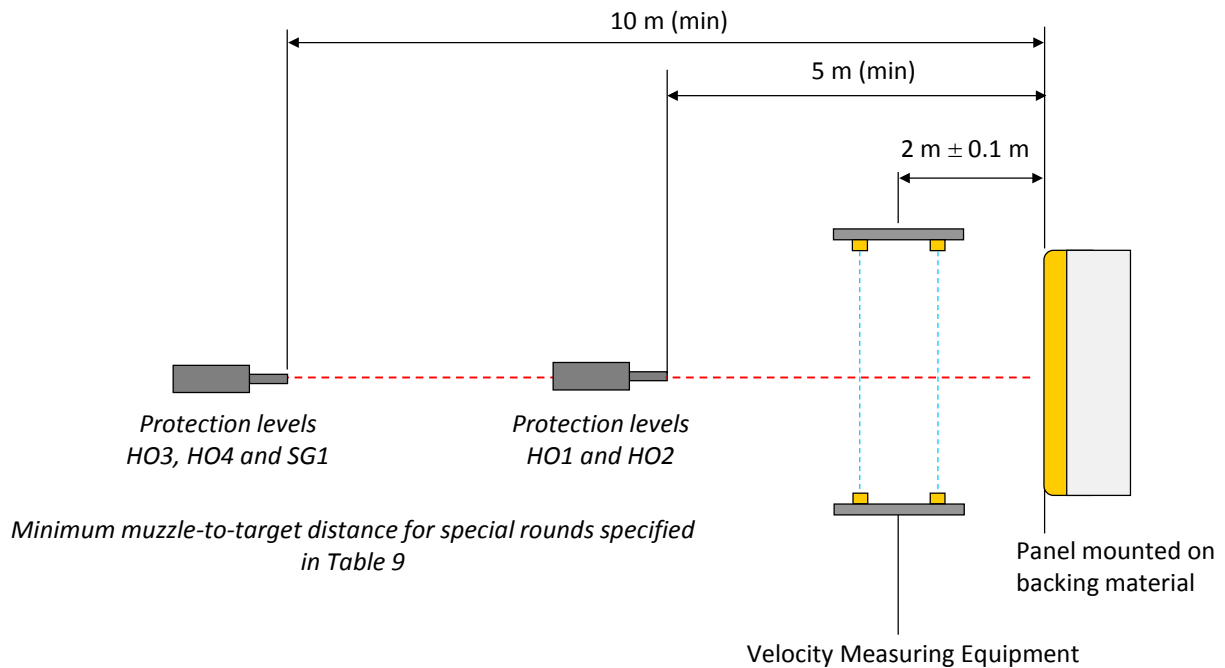
### 6.3.3. Test configuration

Test equipment shall be set up so that the minimum distance from the muzzle of the test barrel to the front surface of the target shall be 5 metres for protection levels HO1 and HO2, and a minimum of 10 metres for protection levels HO3, HO4 and SG1. Minimum muzzle-to-target distances for special ammunition are defined in Table 9.<sup>21</sup>

Figure 9 shows a standard test configuration for ballistic testing.

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<sup>21</sup> CAST shall provide detail on request for additional test rounds not included in Table 9.



**Figure 9: Schematic showing a standard ballistic test configuration**

## 6.4. Sample preparation

### 6.4.1. Conditioning panels

All armour shall be placed in an environment held at a temperature of  $20 \pm 3^\circ\text{C}$  and 40 to 70% relative humidity for a minimum of 12 hours prior to testing. Protective panels shall be laid flat at all times when conditioning and stacked in piles of no more than four panels.

### 6.4.2. Marking panels

Protective panels shall be marked in accordance with the defined shot pattern for each protection level as specified in Table 10. Two asymmetric shot templates are available for each panel size, which can be inverted to give four potential shot patterns. Each pattern shall be used at least once during a test on a particular armour with the exception of formed panels where a fixed shot pattern shall be used. Where more than four panels are assessed, the shot pattern for the additional panels shall be selected at random. The shot pattern used on each panel shall be recorded and presented in the test report. In circumstances where it would be in contravention of shot placement rules (Table 7) to follow the template, the test facility shall identify another suitable location (e.g. on small panels where the shot template cannot be followed).

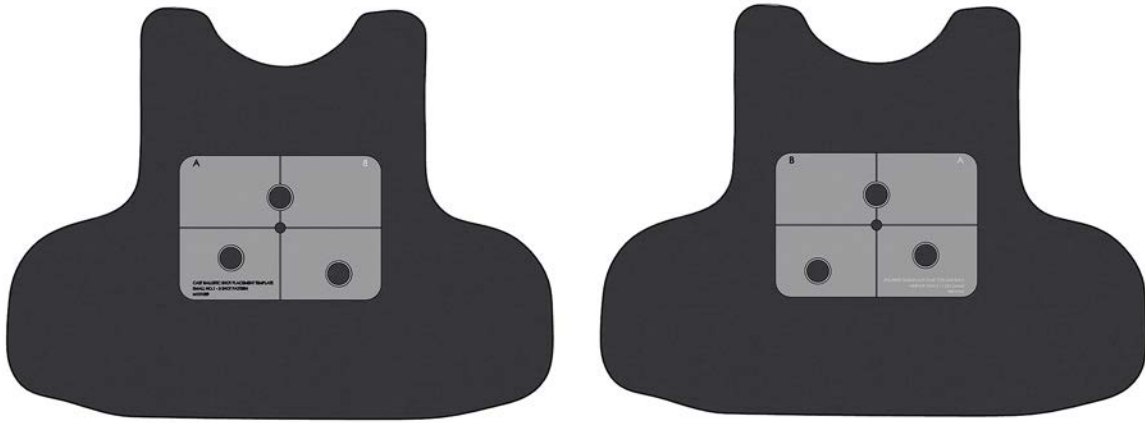
**Table 10: Shot patterns for marking of armour**

Type	Panel size	Number of shots	Angle of shots	Shot pattern <sup>22</sup>
Unformed	Small front	3	3 x 0°	Drawing ref. M101089/M101090 A, B, C or D
	Small rear	3	3 x 0°	
	Medium front	7	6 x 0° 1 x 45°	Drawing ref. M101093/M101094 A, B, C or D
	Medium rear	7	6 x 0° 1 x 30°	
	Large front	7	6 x 0° 1 x 30°	
	Large rear	7	6 x 0° 1 x 45°	
Formed	Small front	4	4 x 0°	Formed shot rules (Section 6.6.3.2)
	Large front	4	4 x 0°	Formed shot rules (Section 6.6.3.2)
Plate (HO3/4)	Front	3	3 x 0°	Drawing Ref. M101091/M101092 A, B, C or D
	Rear	3	3 x 0°	
Plate (SG)	Front	1	1 x 0°	Centremost position on plate
	Rear	1	1 x 0°	
Extended Coverage	Small	1	1 x 0°	Centremost position on plate
	Large	1	1 x 0°	

\* 0° – angle of incidence directly perpendicular to target.

Figure 10 illustrates intended usage for the shot patterns. The centre point shall be identified as the intersection of the centrelines of the armour (from the widest sections) in horizontal and vertical directions. This point shall be used as the alignment position for all shot patterns.

<sup>22</sup> Drawings available on request to CAST.



**Figure 10: Illustration of shot pattern intended usage**

In addition to the standard shot patterns, a further shot shall be positioned on all medium and large panels submitted for testing at a position  $55 \pm 5$  mm from the edge of the panel, defined by the test facility (i.e. seven shots total shall be conducted on medium and large panels). No additional ‘edge’ shots are mandated for formed armour.

## 6.5. Unformed armour testing

### 6.5.1. Backing material preparation

Steel trays measuring  $420 \times 350 \times 100$  mm (length  $\times$  width  $\times$  height) (drawing ref. M100866), open on one large face only, shall be filled with Roma Plastilina<sup>®</sup> No. 1 (Sculpture House, FL, USA) backing material.<sup>23</sup> The backing material in each tray shall be manipulated to ensure no air gaps exist. A smooth, flat top surface shall be produced by scraping the material level with the surface plane defined by the edges of the steel tray. The trays shall be marked with the date they were filled with fresh, out of the packet, Roma Plastilina<sup>®</sup> No. 1 and a unique reference. The contents of the tray shall be disposed of no more than six months after this date.

The backing material trays shall be conditioned in a heated enclosure prior to the start of testing. The temperature shall be set so that the response of the backing material meets the calibration requirements outlined in Section 6.5.2.

### 6.5.2. Calibration methods

After conditioning of the Roma Plastilina<sup>®</sup> No. 1, calibration shall be carried out using the equipment and methods specified below:

- Drop test sphere: steel sphere grade ‘100’.
- Sphere diameter:  $63.5 \pm 0.05$  mm.
- Sphere mass:  $1,043 \pm 5$  g.
- Drop height:  $2.00 \pm 0.02$  m.
- Drop spacing: 75 mm minimum from the edge of the tray to the indent centre and 100 mm between indent centres.

<sup>23</sup> Alternative modelling clays shall not be used.



The calibration drop shall consist of a free fall of the sphere onto the backing material either using a guidance system (e.g. tube of length no greater than 200 mm) or a remote drop mechanism (e.g. electromagnet). A minimum of three drops shall be completed and the arithmetic mean depth of depression shall be  $19 \pm 2$  mm measured from the top edges of the steel tray with no single indentation greater than 22 mm or less than 16 mm. If the backing material response is not within these limits, it should be re-conditioned and re-calibrated prior to use.

Any testing using the calibrated backing material shall be conducted within 1 hour of calibration. After this point, the tray shall be re-conditioned in the heated enclosure.

### 6.5.3. Test methods

#### 6.5.3.1. Mounting of unformed armour

The Roma Plastilina<sup>®</sup> No. 1 backing material tray shall be mounted vertically in the test area against a rigid upright support such that the line of flight of the bullet is perpendicular to its front face. A rigid extension support piece shall be mounted around the ballistic tray extending a minimum of 150 mm in each direction (drawing ref. M101273) (Figure 11). The unformed protective panel, outside of its carrier, shall be fastened to the front face of the backing material using two 50 mm wide hook and loop fabric straps. The edge of the straps shall be secured at least 50 mm from any shot location and, if achievable, more than 100 mm from any shot location. The straps shall be secured by hand, such that the panel is secure but not deformed. The body side of the armour panel shall be in contact with the surface of the backing material.

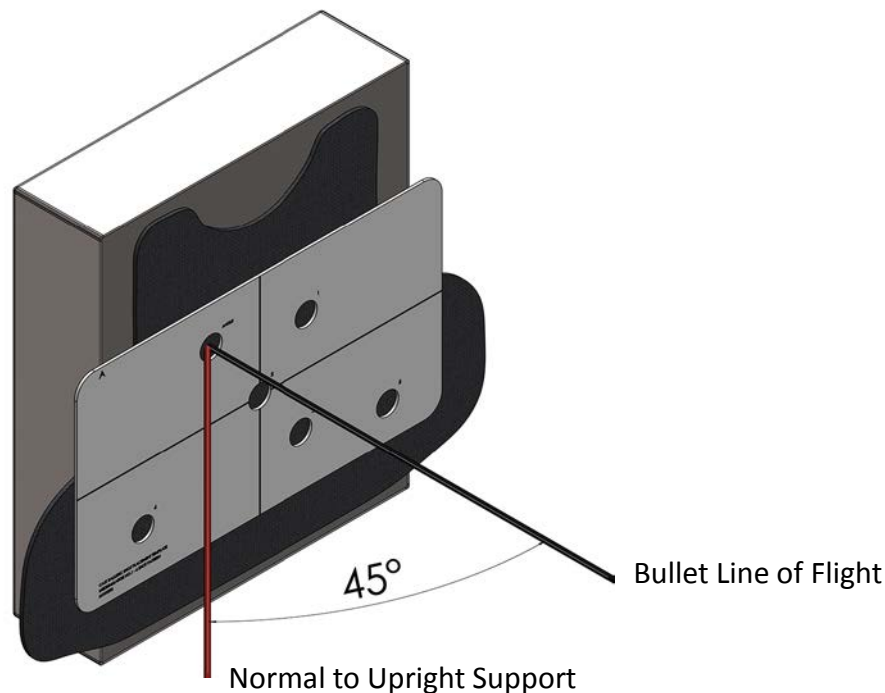


**Figure 11: Ballistic tray mounted with extension support**

### 6.5.3.2. Test shots

Shots shall be performed using the shot patterns specified in Table 10. Following each shot the panel shall be removed from the backing and smoothed<sup>24</sup> before replacing it in the same position so that the next shot may be taken. The surface of the Roma Plastilina<sup>®</sup> No. 1 tray shall also be smoothed without disturbing the BFS of the previous shots. All shots shall be performed before measurements are taken. Bullets trapped in the armour shall not be removed unless impeding the next shot.

An angle shot will be the first shot performed on each panel in accordance with the specifications in Table 10. The protective panels, mounted on the Roma Plastilina<sup>®</sup> No. 1 tray, in succession shall be rotated on the backing material to enable a test to be conducted towards each edge of the armour panel. The setup of this test is shown in Figure 12.

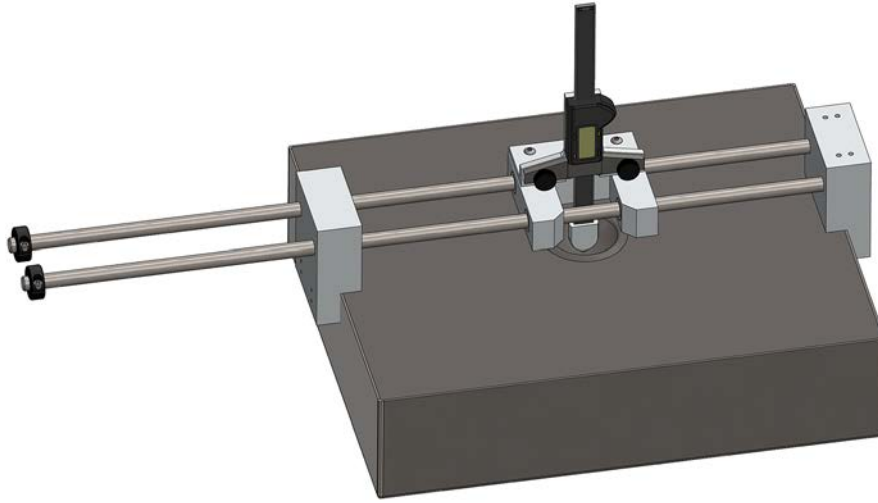


**Figure 12: Images showing the rotation of the protective panel and backing material about the shot normal to achieve a 45° angle**

### 6.5.3.3. Measurements

After all test shots have been performed, the panel shall be removed from the backing material tray. The BFS resulting from each test shot shall be measured using the top edges of the tray as a reference point with an agreed measurement tool. A measurement shall then be taken at the deepest point of the BFS produced by the shot (Figure 13). This shall be repeated for each shot location.

<sup>24</sup> Smoothed – pulled flat and straightened without using any significant physical force (e.g. impacting armour against surface to flatten)



**Figure 13: Example of a measurement of BFS on flat Roma Plastilina<sup>®</sup> tray**

#### 6.5.3.4. Assessments

All assessments shall be carried out in accordance with the performance assessment criteria outlined in Section 6.1.1. Perforation shall be assessed from the body side of the armour. BFS values shall be assessed against the limits specified in Table 8.

#### 6.5.3.5. Backing material repair and re-conditioning

Cavities in the Roma Plastilina<sup>®</sup> No. 1 caused by calibration drop tests or ballistic testing shall be refilled with Roma Plastilina<sup>®</sup> No. 1 that has been conditioned in the same heated enclosure as the main tray. Any debris remaining in Roma Plastilina<sup>®</sup> No. 1 following ballistic testing shall be removed before the cavities are refilled. When refilling, the Roma Plastilina<sup>®</sup> No. 1 shall be pressed firmly into the cavities and smoothed, before the surface of the tray is scraped flat.

#### 6.5.4. Records

The following information shall be recorded after each shot has been conducted and included in the test report:

- Held or perforated.
- Shot velocity measured at  $2 \pm 0.1$  m from front face of panel at the point of aim, measured in  $\text{m.s}^{-1}$  to one decimal place.
- If held:
  - BFS depth, measured in millimetres to one decimal place;
  - BFS profile:
    - Hemispherical;
    - pencilling – if this occurs, measurements and photographs shall be taken and presented with the test report to CAST.
- Details of any fragmentation/spall (if applicable).

After all shots have been conducted, the following information shall be recorded and included in the test report:

- Mean velocity from all shots in test series, recorded in  $\text{m.s}^{-1}$  to one decimal place.
- Mean BFS of all shots in test series, recorded in millimetres to one decimal place.

## 6.6. Formed armour testing

### 6.6.1. Backing material preparation

During material preparation, the female-shaped torso mould (Appendix D) shall be lined with plastic wrap film. Plastiline<sup>®</sup> 40 (G.Lalo, Herbin Sueur SA, France) shall be melted in a suitable container in a heated enclosure at 70°C for approximately 10 hours. Plastiline<sup>®</sup> 40 may separate during the melting process, therefore it shall be stirred at intervals until fully melted. Once melted, the material shall be stirred and then poured into the relevant test mould. On moulding, the mould shall be shaken vigorously by hand for 2 to 3 minutes to remove any porous inclusions before being left to cool for a minimum of 8 hours.

The Plastiline<sup>®</sup> 40 forms shall be conditioned at a minimum temperature of 20°C for a minimum of 3 hours before testing commences. A record shall be kept indicating the date at which the Plastiline<sup>®</sup> 40 form was first moulded with a unique reference assigned. Plastiline<sup>®</sup> 40 forms shall be used within 45 days of preparation.

### 6.6.2. Calibration methods

After conditioning of Plastiline<sup>®</sup> 40, calibration shall be carried out using the following equipment and methods.

- Drop test sphere: steel sphere grade '100'.
- Sphere diameter:  $63.5 \pm 0.05$  mm.
- Sphere mass:  $1043 \pm 5$  g.
- Drop height:  $2.00 \pm 0.02$  m.
- Drop spacing: 75 mm minimum from the edge of the tray to the indent centre and 100 mm between indent centres.

To perform calibration on this shaped backing, the backing material in its mould shall be positioned with the rear face facing upwards in the mould support container (drawing ref. M100879/M100884) (Figure 14). It is recommended that the mould is lined with plastic wrap film during this process to allow ease of removal after calibration. The calibration consists of a free fall drop of the sphere onto the rear of the shaped backing material either using a guidance system (e.g. tube of length no greater than 200 mm) or a remote drop mechanism (e.g. electromagnet). One drop shall be performed on the back of each bust cup (the most built up areas). The arithmetic mean of the two depressions shall be  $7 \pm 2$  mm measured from the top edges of the mould with no single measurement less than 5 mm or greater than 9 mm. If the backing material response is not within these limits, it should be re-conditioned and re-calibrated prior to use.



**Figure 14: Shaped torso backing material calibration configuration**

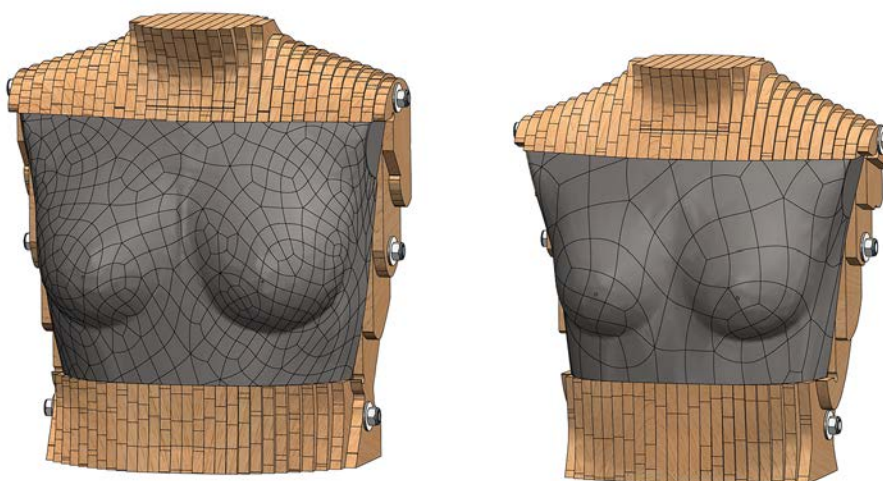
Cavities in the Plastiline® 40 caused by calibration shall be filled with Plastiline® 40 that has been kept in the same heated enclosure as the shaped backing. It shall be pressed firmly into the cavities and smoothed manually before the rear surface of the form is scraped flat. The form may be used immediately following calibration and repair.

Any testing using the calibrated backing material shall be conducted within 1 hour of calibration.

### 6.6.3. Test methods

#### 6.6.3.1. Mounting of formed armour

The moulded Plastiline® 40 female form shall be mounted vertically in the appropriate bust holders (drawing ref. M100831/M100832) against a rigid, upright support, such that the line of flight of the bullet is perpendicular to the flat rear face of the holder (Figure 15).



**Figure 15: Plastiline® 40 female busts in wooden bust holders**

Unformed armour intended for use by female end-users shall be fitted to the female-shaped backing material and tested in accordance with Section 6.6.3.2.

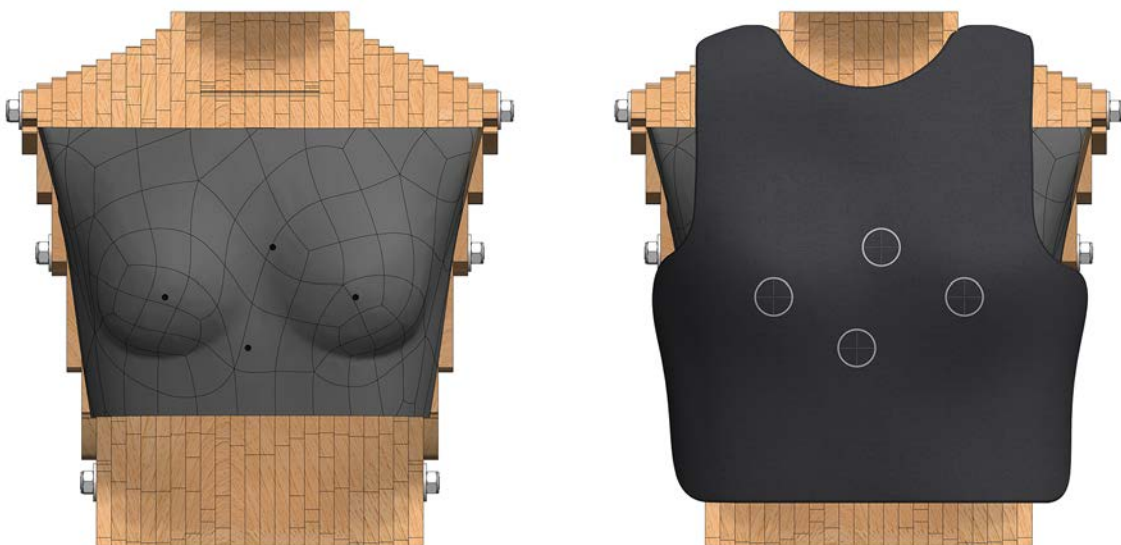
The protective panel, in its carrier, shall be mounted onto the form using its own straps ensuring proper fit over the busts, lining the centremost point of the neck line up with the corresponding position on the form centrally between the busts. Additional strapping may be used where deemed necessary to achieve proper fitting, though care should be taken to ensure the panel is not unnaturally constrained; this shall be noted in the test report provided

to CAST. Note that air gaps are likely to be present between the protective panel and the female form; this is acceptable.

### 6.6.3.2. Test shots

For each test series on formed armour, a standard shot pattern shall be adopted. The standard shot pattern has four shots at the following locations: the left bust tip, right bust tip, top and bottom (in this shot order). Prior to testing, shot locations shall be marked on the formed armour surface (Figure 16) in accordance with the following procedure:

- a) Bust tips (most pronounced positions) and the horizontal midpoint between them shall be marked on the Plastiline<sup>®</sup> 40 bust.
- b) Top and bottom positions shall be marked at positions  $40 \pm 5$  mm in either direction laterally from the midpoint of the horizontal axis and  $10 \pm 2$  mm vertically in either direction from that point.
- c) Laser sight from proof barrel shall be placed on the position you intend to mark (e.g. the left bust tip).
- d) Armour positioned on shaped torso backing material.
- e) Laser sight position marked on the surface of the armour.
- f) Procedure repeated for all shot positions.



**Figure 16: Standard shot pattern locations marked on formed armour**

CAST reserves the right to identify and assess potential perceived areas of weakness in formed armour design, which may be specified to the test facility on approval of the technical file.

All shots shall be performed at an angle such that the line of flight of the bullet is perpendicular to the flat rear face of the wooden bust holders.

In a test series, all shots shall be performed before any assessment is undertaken. If there is significant movement of the armour on the shaped backing material between shots, the armour may be re-positioned and re-fastened.

Shot rules detailed in Table 7 are not applicable for formed armour testing as testing is permitted less than 50 mm from the edge of the panel. Velocity requirements specified in Table 8 must be adhered to. If shots are conducted more than 10 mm from the marked shot centre, these shall be considered unfair shots and additional panels shall be tested.

#### 6.6.3.3. Assessments

All assessments shall be carried out in accordance with the performance assessment criteria outlined in Section 6.1.1. After all shots have been performed, perforation for each test shot shall be assessed from the body side of the armour.

The BFS is not assessed in formed armour testing.

#### 6.6.3.4. Backing material repair and re-conditioning

Cavities in the Plastiline<sup>®</sup> 40 caused by ballistic impact shall be cleared of debris before re-moulding. The backing material shall be re-melted and re-formed following a test series, in accordance with the procedure outlined in Section 6.6.1. Plastiline<sup>®</sup> 40 may be melted and re-formed a maximum of ten times.

#### 6.6.4. Records

The following information shall be recorded after each shot has been conducted and included in the test report:

- Held or perforated.
- Shot velocity measured at  $2 \pm 0.1$  m from front face of panel at the point of aim, measured in  $\text{m.s}^{-1}$  to one decimal place.
- If held, BFS profile:
  - hemispherical;
  - pencilling – if this occurs, measurements and photographs shall be taken and presented with the test report to CAST.
- Details of any fragmentation/spall (if applicable).

After all shots have been conducted, the following information shall be recorded and included in the test report:

- Mean velocity from all shots in test series, recorded in  $\text{m.s}^{-1}$  to one decimal place.

## 6.7. Plate testing

### 6.7.1. Backing material preparation

Roma Plastilina<sup>®</sup> No. 1 shall be used to fill the male shaped front and rear torso moulds (Appendix D), ensuring the material is manipulated such that no air gaps exist. A plastic wrap film is recommended as a liner for the mould to promote ease of material release.

### 6.7.2. Calibration methods

Prior to any testing, the Roma Plastilina<sup>®</sup> No. 1 torso-shaped backing material shall be calibrated in its mould and mould support container (drawing ref. M100889/M100894) in a similar manner to formed armour testing (Section 6.6.2). A plastic wrap film is again recommended as a liner for the mould to promote ease of material release post calibration.

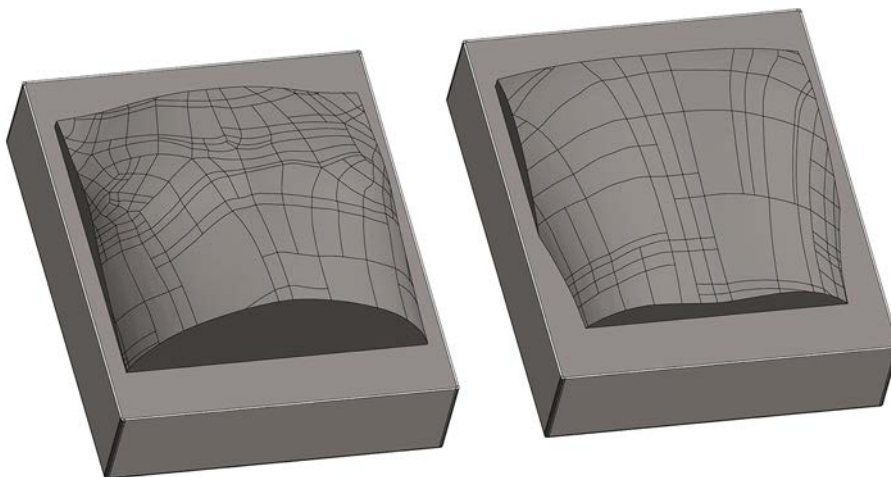
Two calibration drops shall be performed on the rear of the test form, with indent centres a minimum distance of 100 mm apart and 75 mm from any edge of the formed torso backing material. Indentations shall have an acceptable arithmetic mean depth of depression of  $19 \pm 2$  mm measured from the top edges of the up-turned mould with no single indentation greater than 22 mm or lower than 16 mm. If the backing material response is not within these limits, it shall be re-conditioned and re-calibrated prior to use.

Cavities in the Roma Plastilina<sup>®</sup> No. 1 caused by calibration drop tests shall be refilled with Roma Plastilina<sup>®</sup> No. 1 that has been conditioned in the same heated enclosure as the main tray. When refilling, the Roma Plastilina<sup>®</sup> No. 1 shall be pressed firmly into the cavities and smoothed, before the surface of the mould is scraped flat. Any testing using the calibrated backing material shall be conducted within 1 hour of calibration.

### 6.7.3. Test methods

#### 6.7.3.1. Mounting of plates

Torso backing material shall be mounted centrally onto a tray-formed Roma Plastilina<sup>®</sup> No. 1 backing material (Figure 17), which has been stored in the same heated conditioning enclosure.



**Figure 17: Shaped torso backing material test configuration (left: front, right: back)**



The Roma Plastilina<sup>®</sup> No. 1 tray with the shaped male torso form attached shall be mounted vertically in the test area so that the line of flight of the bullet is perpendicular to the flat surface of the rear backing tray. If there are difficulties in adhering the male shaped forms onto the Roma Plastilina<sup>®</sup> No. 1 trays, additional clay material from the same enclosure may be used around the edges to enable improved adhesion. Ballistic shoulders shall be attached to the edges of the flat Roma Plastilina<sup>®</sup> No. 1 tray, as shown in Figure 18.

The plate shall be placed into a suitable plate carrier system. If it is intended to be used in conjunction with certified soft backing armour then this soft armour shall also be installed into the carrier prior to mounting. The armour carrier shall be positioned over the backing material, using the carrier straps where possible, so that the plate is directly over the moulded surface. Additional strapping may be used where deemed necessary to achieve proper fitting, though care should be taken to ensure the panel is not unnaturally constrained; this shall be noted in the test report provided to CAST.

Please note if plates are intended to be worn by female end-users, they shall be tested on the large Plastiline<sup>®</sup> 40 female-shaped backing to assess for perforation only. In such testing, the backing materials shall be prepared, conditioned and mounted in accordance with the methods outlined in Sections 6.6.1, 6.6.2 and 6.6.3.1. All ballistic testing shall be conducted in accordance with Sections 6.7.3.2 to 6.7.3.4. If there is not an equivalent certified plate of the same construction tested on Roma Plastilina<sup>®</sup> No.1 male torso-shaped backing, purpose-made plates shall be submitted in accordance with size requirements and submissions quantities outlined in Sections 4.3.1.3 and 4.3.2, respectively, and the test methods outlined in Section 6.7.

### 6.7.3.2. Pre-test measurements

Prior to testing, shot locations shall be marked on the plate surface using the rifle shot patterns (Figure 18). The following procedure shall then be adopted:<sup>25</sup>

- a) Plate (and, where applicable, soft armour) positioned on shaped torso backing material.
- b) Laser sight from firearm barrel positioned on shot location.
- c) Armour removed and position of laser sight marked on backing material surface.
- d) Backing material marked at four measurement positions, 10 mm from each shot centre along the orthogonal axes.
- e) BFS measurement tool zeroed on flat surface of rear Roma Plastilina<sup>®</sup> No. 1 tray.
- f) BFS measurement tool used to measure the height above the Roma Plastilina<sup>®</sup> No. 1 tray surface of each shot centre and the four marked measurement positions (measurements recorded in millimetres (mm), recorded to one decimal place).
- g) The arithmetic mean of the five marked measurement locations about each shot location shall be calculated.

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<sup>25</sup> Alternative BFS measurement techniques may be used with prior permissions from CAST.



**Figure 18: Marking of shot locations and measurement of pre-shot surface positions**

### 6.7.3.3. Test shots

Shots conducted in accordance with HO3 and HO4 ballistic protection levels shall be performed in the positions specified on the rifle shot pattern. For testing to the SG1 protection level, a single shot shall be conducted in the centre of the plate.

All shots shall be performed at an angle such that the line of flight of the bullet is perpendicular to the flat Roma Plastilina® No. 1 tray backing.

### 6.7.3.4. Post-test measurements

After each test shot has been conducted, the rifle plate shall be removed and measurements shall be taken at the marked positions using parts (e) to (f) of the procedure described in Section 6.7.3.2. The armour shall then be re-positioned on the backing material with subsequent shots marked in accordance with parts (b) to (d) of Section 6.7.3.2.

The BFS values from each shot location shall be calculated as the difference between the pre- and post-test arithmetic means determined from raw unrounded data from measurements made on the shaped torso backing.

### 6.7.3.5. Assessments

All assessments shall be carried out in accordance with the performance assessment criteria outlined in Section 6.6.1. Perforation shall be assessed from the body side of the armour. BFS values shall be assessed against the limits specified in Table 8.

### 6.7.3.6. Backing material repair and re-conditioning

Following testing, the shaped Roma Plastilina® No. 1 torso backing materials shall be placed back into the original mould nested in the support container with the front face covered in plastic wrap film. Any cavities in the backing material shall then be back-filled with Roma Plastilina® No. 1 material that has been conditioned in the same enclosure as the tray; this shall be compressed into the mould and re-conditioned.

## 6.7.4. Records

The following information shall be recorded after each shot has been conducted and included in the test report:

- Held or perforated.
- Shot velocity measured at  $2 \pm 0.1$  m from front face of panel at the point of aim, measured in  $\text{m.s}^{-1}$  to one decimal place.
- If held:
  - position data from each measurement location, measured in millimetres to one decimal place;
  - mean BFS of each shot, recorded in millimetres to one decimal place;
  - BFS profile:
    - hemispherical;
    - pencilling – if this occurs, measurements and photographs shall be taken and presented with the test report to the CAST.
- Details of any fragmentation/spall (if applicable).

After all shots have been conducted, the following information shall be recorded and included in the test report:

- Mean velocity from all shots in test series, recorded in  $\text{m.s}^{-1}$  to one decimal place.
- Mean BFS of all shots in test series, recorded in millimetres to one decimal place.

## 6.8. Critical perforation analysis

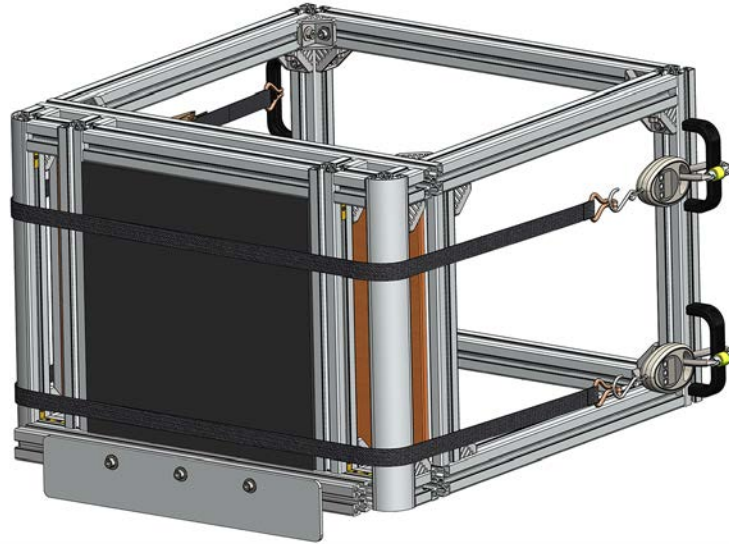
### 6.8.1. Introduction

CPA shall be performed on HO1 and HO2 unformed armour following certification testing where the armour has met the minimum acceptable criteria at the given protection levels. The tests aim to identify the velocity associated to a given statistical probability of body armour perforation. Such values shall be used to inform the performance of the certified armour and as a metric for comparison in PQT (Section 10) and ILM (Section 11).

### 6.8.2. Test configuration

CPA testing shall be conducted using a rigid frame structure with the protective panels mounted onto a  $400 \times 400 \times 100$  mm piece of Plastazote<sup>®</sup> LD29 foam block backed by a flat vertical surface (e.g. 10 mm thick piece of plywood). The foam shall be conditioned in an environment maintained at  $20 \pm 3^\circ\text{C}$  and relative humidity range of 40 to 70% for a minimum of 12 hours before testing commences. A new sheet of foam shall be installed at the start of the CPA test for an armour model and after it becomes significantly damaged such that further shots on undisturbed regions are no longer possible.

Figure 19 illustrates a test rig that could be used for such tests (drawing ref. M100823).



**Figure 19: Example of a CPA test rig**

### 6.8.3. Test methods

For all CPA tests, the MEN 9 mm FMJ DM11A1B2 shall be used, as specified in Table 8. Tests shall be conducted at a range of velocities into a minimum of three large protective panels with shot centres marked off the orthogonal axes of any other shot according to shot placement rules (Table 7). Between six and ten shots shall be performed on each panel; this shall be defined by the manufacturer. The panels shall be mounted in accordance with mounting instructions specified in Section 6.5.3.1.

A minimum of 30 shots shall be performed with the test end conditions governed by the point at which the standard deviation of the  $V_{50}$  is below 10% of the mean. This condition shall be indicated by the CPA software.

### 6.8.4. Software and test instructions

CPA software, *DOSG Perforation Tool*<sup>26</sup> shall be installed according to the developer's guidelines. Recommended usage for the software has been outlined below.

- a) Enter contextual information for the test (i.e. agency, target, ammunition, date and range).
- b) Select the protection level the armour has been tested to. This will update provide the software with the confidence limits detailed in Table 11.

**Table 11: CPA confidence limits**

Protection level	Lower Confidence Limit (m.s <sup>-1</sup> )	Upper Confidence Limit (m.s <sup>-1</sup> )
HO1	300	600
HO2	350	650

<sup>26</sup> To be provided by CAST on request.

- c) Based on the suggestions given by the software, adjust powder mass to attain specified velocity.
- d) Conduct the ballistic shot in the marked location.
- e) Measure the velocity and record in the software.
- f) Check to see whether the armour has perforated and record this information into the software (0 = non-perforation; 1 = perforation; 2 = ignore record.<sup>27</sup>)
- g) Further velocity suggestions will be made by the software based on the outcome of each shot, repeat steps (c) to (f) for future shots until end condition met.

### 6.8.5. Assessments

Pass criteria for  $V_{01}$  are values of  $375 \text{ m.s}^{-1}$  and  $440 \text{ m.s}^{-1}$  for HO1 and HO2 protection levels, respectively.

$V_{50}$  values are, at this stage, not involved in assessments but shall be used for comparative purposes in subsequent PQT (and ILM) evaluations.

### 6.8.6. Records

On completion of a CPA test,  $V_{01}$  and  $V_{50}$  values given by the software shall be recorded. The data sheet containing submitted information shall be saved using the following naming convention:

CPA – [Manufacturer] – [Armour Model] – [Test Facility Name] – [Protection Level] – [Date]

This file shall be submitted to CAST alongside the certification test report.

## 6.9. Additional ballistic tests

Additional shots may be performed at perceived points of weakness on the protective panels. The test facility is authorised to identify potential points of weakness for testing purposes on CAST's approval. CAST may also instruct the test facility to conduct tests on specific locations of the panel, which will be determined on review of the technical file.

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<sup>27</sup> To be used in instances where there is an unfair shot (based on distance only) or insufficient data has been recorded (e.g. velocity not measured).

## 6.10. Extended coverage

### 6.10.1. Test configuration

#### 6.10.1.1. Soft armour panels

Extended coverage panels of a soft armour construction shall be assessed on a flat Roma Plastilina<sup>®</sup> No. 1 tray prepared, conditioned and calibrated in the same manner as unformed armour outlined in Sections 6.5.1 and 6.5.2.

Soft extended coverage panels shall be mounted using two 50 mm wide hook and loop fabric straps adjusted by hand such that the panel is secure but not deformed and the body side of the protective panel is in contact with the surface of the backing material.

#### 6.10.1.2. Hard armour panels

Extended coverage panels of a hard armour construction (plates) shall be mounted on a flat Roma Plastilina<sup>®</sup> No. 1 tray prepared, conditioned and calibrated in the same manner as unformed armour outlined in Sections 6.5.1 and 6.5.2 and back-filled with conditioned Roma Plastilina<sup>®</sup> No. 1 material into the armour cavities.

Hard extended coverage panels shall be mounted using two 50 mm wide hook and loop fabric straps adjusted by hand such that the panel is secure but not deformed and the body side of the protective panel is in contact with the surface of the backing material.

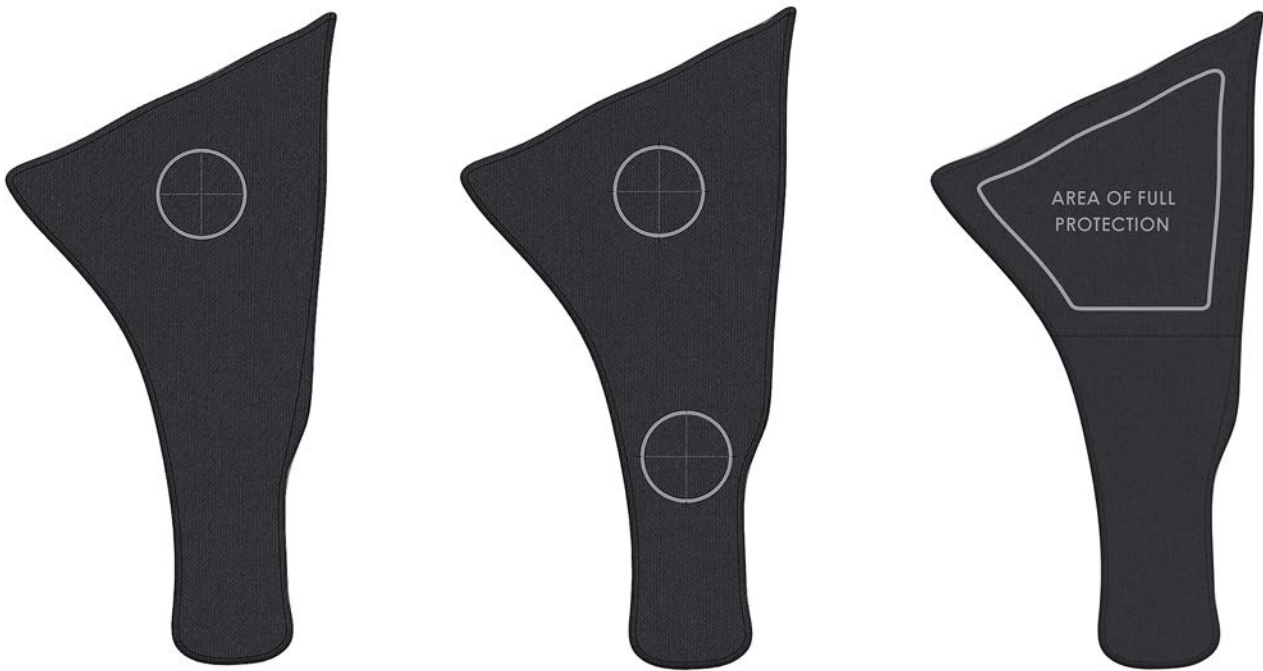
### 6.10.2. Shot marking

The centremost point on the panel shall be marked as the shot centre based on the intersections of the centrelines of the armour (from the widest sections) in horizontal and vertical directions, as shown in Figure 20. In some instances, these locations may not comply with the shot placement rules outlined in Section 6.1.4; this is acceptable.



**Figure 20: Example shot marking on extended coverage panels**

On panels where there is a tapering in geometry equating to a change in width greater than 50% of the panels widest point, the manufacturer must either stipulate an area of full protection or subject the panel to testing on the tapered region as well as the main body. In these instances, the performance of the panel will be considered as a whole. This is illustrated in Figure 21.



**Figure 21: Example of shot marking on tapered extended coverage panels**

### 6.10.3. Test methods

Extended coverage panels shall be tested using the ammunition detailed in Table 8 for each protection level. Two shots shall be conducted per ammunition type; one on small and one on large panels.

All shots shall be performed in an orientation such that the line of flight of the bullet is perpendicular to the flat front face of the Roma Plastilina<sup>®</sup> No. 1 backing material.

### 6.10.4. Assessments

All assessments shall be carried out in accordance with the performance assessment criteria outlined in Section 6.1.1. After each shot has been performed, perforation shall be assessed from the body side of the armour.

BFS is not assessed in extended coverage panels.

### 6.10.5. Records

The following information shall be recorded after each shot has been conducted and included in the test report:

- Held or perforated.
- Shot velocity measured at  $2 \pm 0.1$  m from front face of panel at the point of aim, measured in  $\text{m}\cdot\text{s}^{-1}$  to one decimal place.
- If held, BFS profile:
  - hemispherical;
  - pencilling – if this occurs, measurements and photographs shall be taken and presented with the test report to CAST.
- Details of any fragmentation/spall (if applicable).

After all shots have been conducted, the following information shall be recorded and included in the test report:

- Mean velocity from all shots in test series, recorded in  $\text{m.s}^{-1}$  to one decimal place.

## 6.11. Reporting

Reporting of all ballistic tests shall follow the template provided by CAST.<sup>28</sup> This completed report shall be sent to CAST alongside any associated relevant information (e.g. photographs) on completion of tests.

All test reports will be protectively marked as 'OFFICIAL SENSITIVE [COMMERICAL]' with handling instructions 'for use by the Home Office, stated manufacturer and stated test facility only, unless otherwise agreed by all parties' and kept on record for a minimum of five years.

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<sup>28</sup> To be issued to test facilities in a separate file.



# 7. Stab testing

## 7.1. General stab testing requirements

### 7.1.1. Performance assessment criteria

All stab resistant armour, regardless of protection level, shall not exceed the penetration limits defined in Table 13 for the associated protection level being assessed.

### 7.1.2. Fair strike

A fair strike shall be recorded if:

- the energy of the stab falls within the defined tolerance in Table 14;
- the stab placement rules, defined in Table 12, are adhered to;
- unless otherwise specified, the stab is perpendicular to the target.

Any strike that does not meet the fair strike criteria will be classed as unfair and repeated unless covered by exceptions in Section 7.1.3.

### 7.1.3. Exceptions

The following conditions represent exceptions to the fair strike criteria for stab testing:

- If the stab energy is below the specified range but the depth of penetration limits are exceeded; this shall be classed as a fair strike.
- If the stab energy is above the specified range and the depths of penetration requirements are met; this may be classed as a fair strike upon acceptance by the manufacturer. Beyond this point, any subsequent fair strikes are considered acceptable.
- If the stab placement rules are not adhered to and the depth of penetration requirements are met; this may be classed as a fair strike upon acceptance by the manufacturer. Beyond this point, any subsequent fair strikes are considered acceptable.

If the manufacturer considers an unfair strike, which they have not accepted, to have compromised the continued performance of the panel under test they may request that a full re-test of that panel is completed. In these circumstances, the manufacturer shall provide an additional panel to the test facility for testing.

### 7.1.4. Strike placement rules

Strikes shall be positioned according to strike rules outlined in Table 12.

**Table 12: Stab strike placement rules**

Panel type	Min. strike-to-strike distance	Min. strike-to-edge distance <sup>29</sup>
Unformed	50 mm	50 mm
Formed	n/a	n/a
Extended coverage	n/a	n/a

## 7.2. Protection levels

There are two knife protection levels, each of which can be upgraded to include spike protection. For each knife protection level, two stab energies are assessed, E1 and E2. Spike is only assessed at E1. The test energies and associated permissible depths of penetration are shown in Table 13. For each knife protection level there is a single penetration limit (SPL), which defines a maximum permissible penetration for a single stab in a test series.

**Table 13: Stab protection levels**

Protection level	Energy level E1			Energy level E2		
	Energy (J)	Maximum penetration at E1 (mm)	SPL at E1 (mm)	Energy (J)	Maximum penetration at E2 (mm)	SPL at E2 (mm)
KR1	24.0	8.0	9.0	36.0	20.0	30.0
KR1 + SP1	24.0	KR1 = 8.0, SP1 = 0	KR1 = 9.0, SP1 = 0	36.0	KR1 = 20.0, SP1 = N/A	KR1 = 20.0, SP1 = N/A
KR2	33.0	8.0	9.0	50.0	20.0	30.0
KR2 + SP2	33.0	KR2 = 8.0, SP2 = 0	KR1 = 9.0, SP2 = 0	50.0	KR2 = 20.0, SP2 = N/A	KR2 = 30.0, SP2 = N/A

At energy E1, one penetration in a test series is permitted up to 9.0 mm. All other penetrations must be 8.0 mm or below. These values are absolute and no rounding is permitted.

At energy E2, one penetration in a test series is permitted up to 30.0 mm. All other penetrations must be 20.0 mm or below. As with E1 these values are absolute and no rounding is permitted.

Spike is only assessed at energy E1. No penetrations are permitted.

<sup>29</sup> Distances specified from the edge of the cut to the edge of the armour and/or the edge of the backing material.

### 7.3. Energy requirements

The stab energy shall be calculated from the recorded velocity and mass of the sabot/blade assembly using Equation (1) and reported in joules to one decimal place.

$$E = \frac{1}{2}mv^2 \quad (1)$$

Where E = energy in joules, m = mass in kg and v = velocity in m.s<sup>-1</sup>.

The energy of each stab shall be within the defined tolerance shown in Table 14. The minimum and maximum values shown are absolute, no rounding up (to minimum) or down (to maximum) is permitted.

**Table 14: Stab energy permitted tolerances**

Energy level		Specified energy (J)	Minimum energy (J)	Maximum energy (J)
KR1	E1	24	23.5	25.0
	E2	36	35.3	37.4
KR2	E1	33	32.3	34.3
	E2	50	49.0	52.0

### 7.4. Environmental test conditions

The test facility, storage rooms and associated areas shall be maintained at a temperature of 20 ± 3°C and 40 to 70% relative humidity. The working temperature and relative humidity of all areas shall be recorded on the test report.

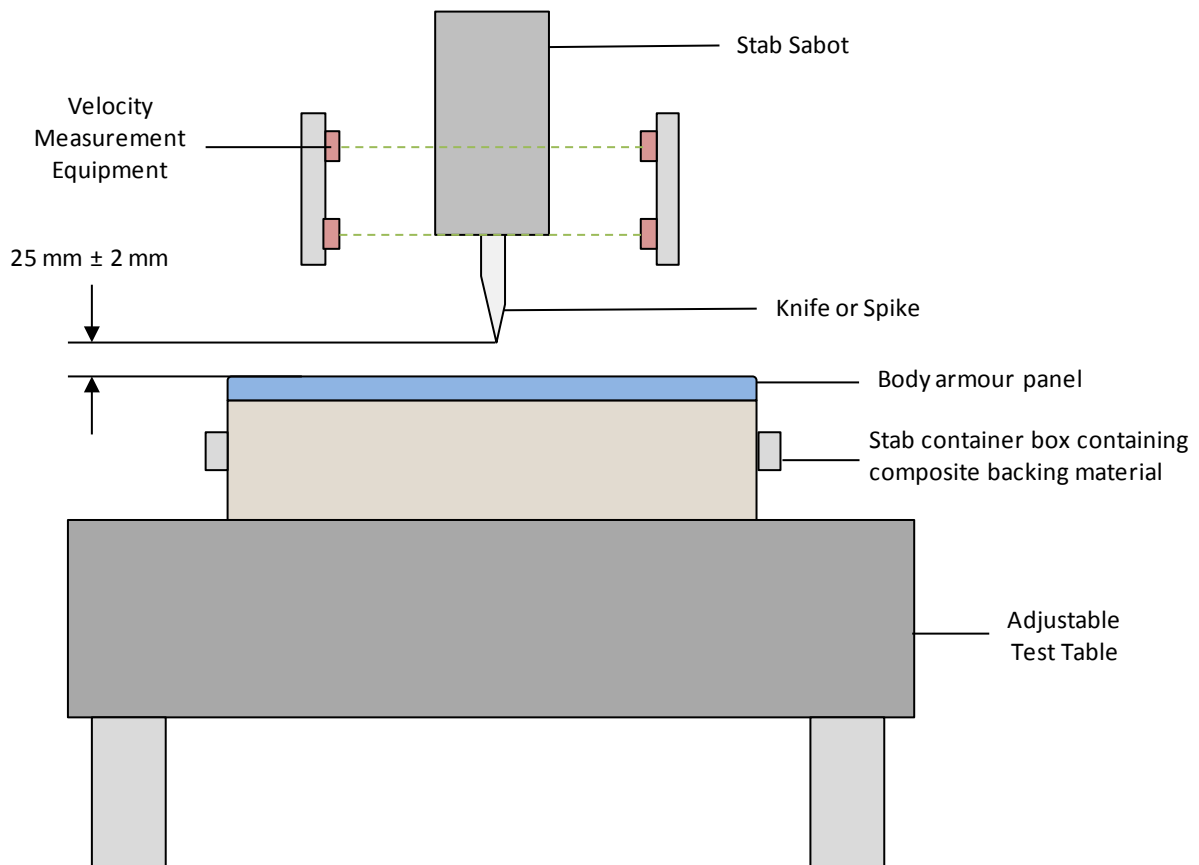
### 7.5. Test equipment

#### 7.5.1. Calibration and records

The stab sabot and measurement equipment listed in this section shall be calibrated in accordance with internal quality management systems. All accredited test facilities shall have equipment approved by CAST. Calibration records shall be made available to CAST upon request. Details of equipment used during each test shall be recorded on the test report.

## 7.5.2. Test configuration

Figure 22 illustrates a typical test configuration for stab testing.



**Figure 22: Schematic of a typical stab test configuration**

## 7.5.3. Guided-mass drop assembly

Tests shall be performed using a guided-mass, gravity-driven, drop test assembly. In this assembly, a sabot with a knife or spike end-effector shall be raised to a pre-determined height corresponding with the test energy. The sabot shall then fall, under the influence of gravity, and strike the protective panel at a pre-determined point of impact (see Table 12 for strike placement rules). The guided rails shall prevent the sabot from rotating about its vertical axis during its descent to ensure that the knife strikes in the correct orientation (not applicable for spike).

An example of a drop assembly for stab testing is given in drawing ref. M100770.<sup>30</sup>

## 7.5.4. Stab sabot

The stab sabot (drawing ref. M100668)<sup>31</sup> shall consist of a knife or spike holder (drawing ref. M100670) of mass  $650 \pm 6.5$  g (including the knife or spike) which shall be housed in a casing of mass  $1,250 \pm 13$  g (combined acceptable mass:  $1,900 \pm 20.5$  g). The knife or spike holder shall be free to move in the vertical axis within the casing, whilst being constrained to restrict rotational movement. The casing shall be designed to ensure minimal friction between the two

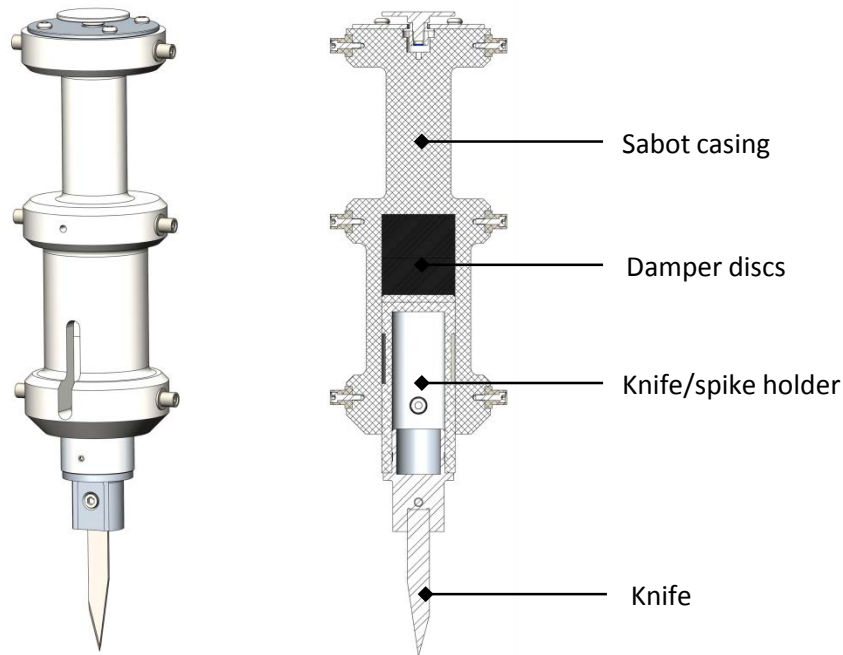
<sup>30</sup> Drawings available on request to CAST.

<sup>31</sup> Drawings available on request to CAST.

components. The stab sabot shall contain two closed-cell polyethylene foam Plastazote<sup>®</sup> LD33 discs behind the knife or spike holder, which act as a damper. On insertion of the knife/spike holder into the stab sabot, the discs shall remain under compression with their total thickness reduced by  $5 \pm 0.5$  mm. The knife or spike shall be securely held within the holder to limit movement during tests.

The overall stab sabot length shall be sufficient to ensure that at least 50% of it remains inside the guided drop test assembly throughout a test.

An example of a stab sabot for testing to this standard is given in Figure 23.



**Figure 23: Section view through stab sabot**

#### 7.5.5. Knife

The test blade shall be sourced from a Home Office approved supplier (Appendix D). It shall be manufactured in accordance with drawing reference M100598 and batch certified in accordance with the Cutlery and Allied Trades Research Association (CATRA) procedure HO/K with a value of  $\leq 3.47$  N.

Prior to use, each knife shall be wiped clean with an alcohol based degreasing wipe or similar taking care not to damage the tip. A knife shall be used only once; following each stab it shall be replaced.

#### 7.5.6. Spike

The test spike shall be sourced from a Home Office approved supplier (Appendix D). It shall be manufactured in accordance with drawing reference M100634 and batch certified in accordance with the CATRA procedure HO/S with a value of  $\leq 4.5$  N.

Prior to use, each spike shall be wiped clean with an alcohol based degreasing wipe or similar. A spike shall be used only once; following each stab it shall be replaced.

### 7.5.7. Stab dampers

The dampers shall be cut from a sheet of closed-cell polyethylene foam Plastazote<sup>®</sup> LD33 that has been stored flat for a minimum of 24 hours prior to use. The dampers shall be cut to leave a smooth, parallel edge.

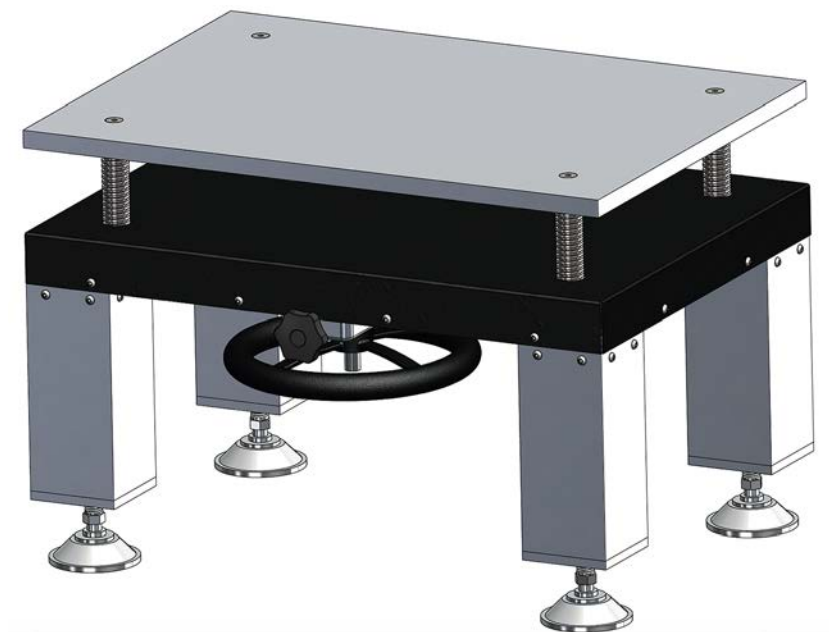
The dampers, individually, when cut shall have the following specification:

- Diameter:  $50 \pm 0.5$  mm
- Thickness per damper:  $30 \pm 1$  mm

Each set of two dampers used within the stab sabot shall have a collective thickness of  $60 \pm 1$  mm. These dampers shall be used for a maximum of five stabs prior to replacement.

### 7.5.8. Test table

The test table is a rigid component in the stab test assembly supporting the stab backing materials; it shall be positioned on a flat, rigid surface. The test table shall be adjustable to enable the protective panel to be raised or lowered to ensure that it is positioned in accordance with the test requirements. An example of such a test table is shown in Figure 24.



**Figure 24: Example of adjustable table for stab testing**

### 7.5.9. Stab backing container

Stab backing materials shall be placed into a rigid surround such as the container in Figure 25. The top layer of the backing material shall be level with the surround to form a continuous surface that extends a minimum of 60 mm in each direction.



**Figure 25: Stab backing material container**

### 7.5.10. Velocity measurement

All velocities shall be recorded when the tip of the knife or spike is  $25 \pm 2$  mm from the surface of the armour. The velocity of each strike shall be recorded in metres per second ( $\text{m}\cdot\text{s}^{-1}$ ), reported to two decimal places.

It is recommended that a light gate system is adopted with a minimum sample rate of 30 kHz and a base length of  $50 \pm 2$  mm. Alternative systems may be used, however, details of the system must be submitted to CAST and approved as an appropriate method prior to use.

### 7.5.11. Depth of penetration measurement

To measure the depth of penetration of the knife into the armour following a strike, a calibrated rule and a digital microscope are required.

The rule shall be accurate to 1 mm, whilst the microscope shall possess a minimum zoom of  $20\times$  and a minimum resolution of  $1,024 \times 1,024$  pixels; it shall permit measurements to an accuracy of 0.01 mm.

## 7.6. Sample preparation

### 7.6.1. Conditioning panels

All armour shall be placed in an environment held at a temperature of  $20 \pm 3^\circ\text{C}$  and 40 to 70% relative humidity for a minimum of 12 hours prior to testing. Protective panels shall be laid flat at all times when conditioning and stacked in piles of no more than four panels.

### 7.6.2. Marking panels

#### 7.6.2.1. Unformed armour

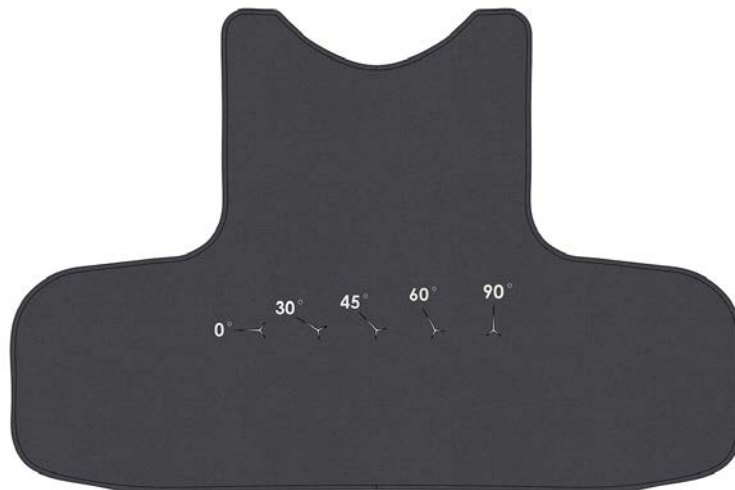
Strikes shall be performed on unformed protective panels in accordance with the strike rules defined in Section 7.1.4 on panel sizes shown in Table 15. For unformed armour, strikes on each specified size shall be performed on a single panel, unless this is in contravention of strike placement rules in which case an additional panel may be used.

**Table 15: Unformed armour stab test quantities**

Panel size	No. of panels		Energy level	No. of strikes	
	Knife	Spike		Knife	Spike
Small	1	1*	E1	5	5
			E2	2 (45°, 90°)	n/a
Medium	1		E1	10	n/a
			E2	2 (45°, 60°, 90°)	n/a
Large	1	1*	E1	15	10
			E2	5	n/a

\* If necessary, where applicable spike tests may be conducted on the same panels used in knife testing adhering with strike placement rules defined in Table 12.

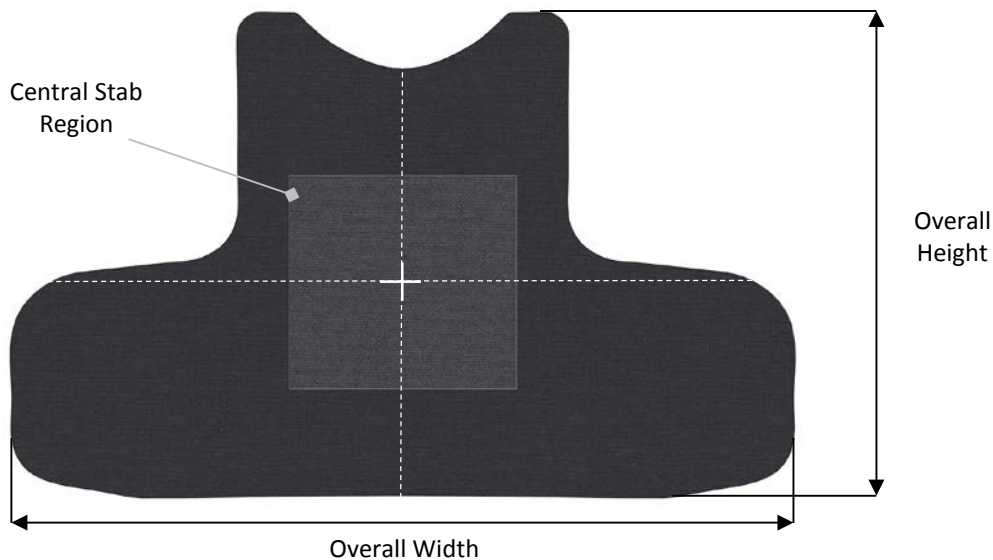
Each knife strike shall be conducted in a different orientation. Unless otherwise specified in Table 15, these orientations shall be at 0°, 30°, 45°, 60° and 90° aligned to the long axis of the protective panel (Figure 26). The protective panel shall be rotated to achieve these orientations.



**Figure 26: Image showing intended orientation of knife strikes on a protective panel**

Prior to conducting any stab testing, all stab locations shall be marked onto the panel. A central stab region shall be drawn by first identifying the centremost point on the panel, defined by the intersection of the centrelines of panel (from the widest point) in vertical and horizontal directions. A box extending 25% of the overall height of the panel in each direction shall be drawn from this centre point (Figure 27). Proportionally, 80% of strikes shall be conducted in the centre of the protective panel. The remaining strikes shall be conducted outside of this area in accordance with strike placement rules (Table 12).





**Figure 27: Knife strike placement on unformed protective panels**

On medium and large unformed armour panels, at least one E1 energy level strike shall be performed at a location  $55 \pm 5$  mm from the edge of the panel, defined by the test facility.

#### 7.6.2.2. Formed armour

For formed armour testing, separate panels are required for knife and spike testing on each size due to the prescribed locations of the strikes being performed. Table 16 shows the quantities of knife and spike strikes required on each size of armour for each protection type (i.e. two small and two large formed armour panels would be required for knife and spike protection).

**Table 16: Formed armour stab test quantities**

Panel size	No. of panels	Energy level	No. of strikes
Small	1	E1	4
Large	1	E1	4

The protective panel shall be marked in accordance with the positions specified in Section 6.6.3.2. Knife strikes shall be conducted at orientations  $0^\circ$ ,  $30^\circ$ ,  $45^\circ$  and  $90^\circ$  aligned to the long axis of the protective panel; applied at the discretion of the test facility.

Four strikes shall be performed (in this strike order) at positions: left bust tip, right bust tip, top and bottom.

CAST reserves the right to identify and assess potential areas of weakness for testing specified to the test facility on approval of the technical file.

The same strike locations shall be followed on additional panels for spike testing.

### 7.6.2.3. Extended coverage

For extended coverage panels, separate panels are required for knife and spike testing on each size due to the prescribed locations of the stabs being performed. Table 17 shows the quantities of knife and spike strikes required on different sizes of armour. A single strike shall be positioned in the centre of the panel. All strikes shall be aligned at a 0° angle with the long axis of the panel.

**Table 17: Extended coverage panel stab test quantities**

Panel size	No. of panels		Energy level	No. of strikes	
	Knife	Spike		Knife	Spike
Small	1	1	E1	1	1
Large	1	1	E1	1	1

## 7.7. Unformed armour testing

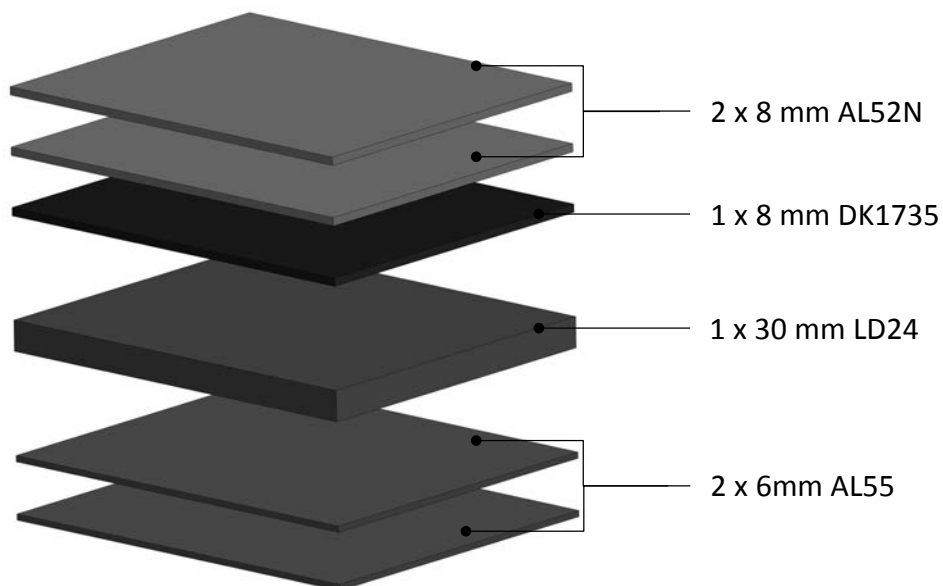
### 7.7.1. Backing materials

A composite pack of backing materials described below shall be positioned beneath protective panels in stab testing on unformed armour. This backing material pack (Appendix D) shall comprise (from armour strike face downwards):

- 2 x 8 mm sheets of AL52N Expanded Nitrile / NBR Sponge;
- 1 x 8 mm sheet of DK1735 Expanded Firm Neoprene Sponge Rubber;
- 1 x 30 mm sheet of LD24 Plastazote<sup>®</sup> closed-cell polyethylene foam;
- 2 x 6 mm sheets of AL55 solid natural rubber.

All materials in this pack have dimensions of 400 × 333 mm (length × width).

The materials shall be configured in the same order as in Figure 28.



**Figure 28: Composite stab backing material pack**

All backing materials shall be placed in an environment held at a temperature of  $20 \pm 3^{\circ}\text{C}$  and 40 to 70% relative humidity for a minimum of 12 hours prior to testing.

All of the composite stab backing materials, excepting the solid natural rubber, shall be replaced after all tests have been conducted for a single certification test or when the foam becomes visibly damaged.

The backing materials shall be placed into the stab backing container (Figure 25) for both calibration and stab testing.

### 7.7.2. Calibration methods

Prior to testing, calibration shall be performed on the composite pack of stab backing materials using the methods and equipment specified below:

- Drop test sphere: steel sphere grade '100'.
- Sphere diameter:  $0.5 \pm 0.05$  mm.
- Sphere mass:  $1,043 \pm 5$  g.
- Drop height:  $1.50 \pm 0.02$  m.
- Drop spacing: 75 mm minimum from any edge to indent centre and 100 mm between indent centres.

The calibration drop shall consist of a free fall release of the sphere onto the backing material, positioned on a flat, rigid, surface, either using a guidance system (e.g. tube of length no greater than 150 mm) or a remote drop mechanism (e.g. electromagnet). Three drops shall be completed and the rebound height shall be  $425 \pm 75$  mm, measured from the top surface of the backing material pack to the bottom of the sphere.

A minimum of 10 minutes shall be left post calibration to allow for material recovery prior to testing.

### 7.7.3. Test methods

#### 7.7.3.1. Mounting of unformed armour

The armour shall be secured using two 50 mm wide hook and loop fabric straps adjusted by hand such that the panel is restrained but not deformed and the body side of the protective panel is in contact with the surface of the backing material. The straps, where possible, shall be at least 100 mm from the strike location and, in no circumstances, less than 50 mm.

It shall be possible to rotate and move the backing material under the guided drop assembly to allow the armour to be tested in different locations and orientations.

#### 7.7.3.2. Test strikes

Test strikes shall be conducted in accordance with the energy levels specified in Table 13 and strike placement rules in Table 12. The stab sabot shall be raised to a defined height to achieve the required energy of impact; it shall then be released and fall under the influence of gravity onto the protective panel.

When the stab is completed, the knife or spike shall be removed from the sabot carefully so that any penetration of the knife or spike may be measured from the body side of the protective panels. Depth of penetration shall be assessed before the panel is re-positioned on the

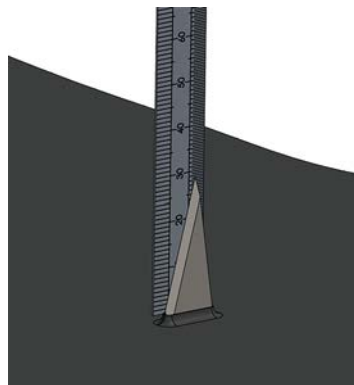
backing material. The new strike shall be positioned a minimum of 50 mm from the closest edge of the previous cut location on the backing material.

Each strike shall be performed with a new knife or spike; sabot dampers shall be replaced after a maximum of five stabs. A minimum of 5 minutes shall be left between each strike to allow for materials to recover. The time of each strike shall be recorded. At the start of a test series, the dampers shall be replaced.

## 7.7.4. Measurements

### 7.7.4.1. Knife

If the knife is visible on the body side of the protective panel, a calibrated rule shall be used initially to provide an indicative measure of the visible length of the knife as shown in Figure 29. Note, the knife shall not be moved or manipulated prior to measurement.



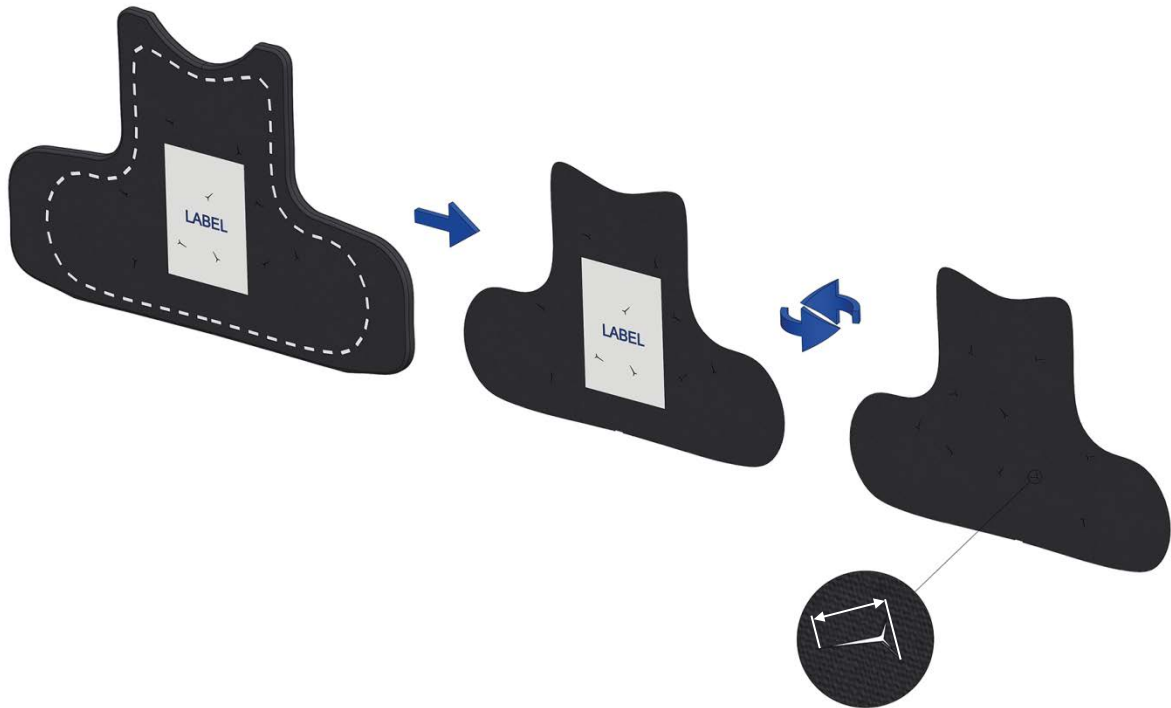
**Figure 29: Calibrated rule knife depth of penetration measurement**

Following such measurement:

- If the depth of penetration, measured by rule, is above 12 mm for E1 strikes or above 33 mm for E2 strikes, no further measurements are required.
- If the depth of penetration is 12 mm or below for E1 strikes or 33 mm or below for E2 strikes, the cut length shall be measured using cut length techniques outlined below.

The knife shall be carefully removed vertically from the protective panel so that the cut length on the body side of the panel is not disturbed.

After all stabs have been performed, the body side of the armour cover shall be cut and removed from the rest of the protective panel such that the inside surface of this cover is visible. The cut lengths shall then be measured on the inside of the cover using a calibrated digital microscope. The microscope shall be focussed over the cut and an image shall be taken. If there is insufficient contrast in the image to clearly identify the length of the cut, a chalk spray may be used directly over the cut area prior to taking the image. Appropriate image processing software shall be used to digitally measure the cut length. Cut lengths shall be measured in millimetres to two decimal places. The procedure for measurement of cut length is illustrated in Figure 30. Care should be taken to ensure any areas of tearing are not included in the measurement.



**Figure 30: Cut length measurement determining depth of penetration**

The cut length shall be converted to depth of penetration using Equation (2).

$$\text{Depth of penetration (mm)} = \text{cut length (mm)} \times 2.396 \quad (2)$$

#### 7.7.4.2. Spike

Measurement of penetration depth is not required following a spike test. The protective panel shall be examined solely for evidence of perforation. This shall be determined if:

- the spike is visible on the body side of the panel, or,
- there is evidence that the body side of the panel has been pierced by the spike.

#### 7.7.5. Assessments

Depth of penetration measurements from each knife and spike strike shall be assessed against the acceptable limits specified in Table 13.

#### 7.7.6. Records

The following information shall be recorded after each strike has been conducted and included in the test report:

- Time at which strike performed.
- Velocity measured  $25 \pm 2$  mm from the surface, measured in  $\text{m.s}^{-1}$  to one decimal place.
- Energy, measured in joules to one decimal place.
- Ruler measurement for depth of knife penetration (where over specified limits), measured in millimetres to one decimal place.
- Any spike perforation (if applicable).

After all strikes have been conducted, the following information shall be recorded and included in the test report:

- Cut length of each knife strike (where below specified limits), measured using digital microscope in millimetres to two decimal places.<sup>32</sup>
- Depth of knife penetration, recorded in millimetres to two decimal places.
- Mean velocity from all strikes in test series, recorded in  $\text{m.s}^{-1}$  to one decimal place.
- Mean energy from all strikes in test series, recorded in joules to one decimal place.

## 7.8. Formed armour testing

### 7.8.1. Backing materials

All formed protective panels shall be assessed using Plastiline<sup>®</sup> 40 shaped backing materials prepared, conditioned and calibrated in accordance with methods outlined in Sections 6.6.1 and 6.6.2.

### 7.8.2. Test methods

#### 7.8.2.1. Mounting of formed armour

The moulded, conditioned and calibrated Plastiline<sup>®</sup> 40 female form shall be mounted in the wooden bust holders (drawing ref. M100831/M100832). A standard strike pattern shall be adopted following the same positioning instructions as Section 6.6.3.2.

Flat regions shall be induced in the areas directly beneath each of the strike locations to prevent 'drag cuts'. These regions shall be 20 mm in diameter and shall be produced by depressing the local region under the strike location with a flat rigid object.

The panel, in its test carrier, shall be mounted onto the conditioned shaped torso backing using its own straps, lining the centremost point of the neck line up with the corresponding position on the form centrally between the busts. Additional straps may be used if considered necessary; this shall be included in the test report. Note that air gaps are likely to be present between the protective panel and the backing material; this is acceptable.

The assembly shall then be laid horizontally on the test table as shown in Figure 31.

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<sup>32</sup> A digital image of each cut length, taken using the microscope, shall be stored on record.



**Figure 31: Formed armour stab test configuration**

### 7.8.2.2. Test strikes

Test strikes shall be conducted in accordance with the energy levels in Table 13.

Each strike shall be performed with a new knife or spike; stab sabot dampers shall be replaced after a maximum of five stabs. A minimum of 5 minutes shall be left between each stab to allow for materials to recover. At the start of a test series on a new construction, the dampers shall be replaced.

Strike rules detailed in Table 12 are not applicable for formed armour testing as testing is permitted less than 50 mm from the edge of the panel. Energy requirements specified in Table 14 must be adhered to.

### 7.8.2.3. Measurements

Measurements for knife and spike strikes shall be conducted directly on the Plastiline<sup>®</sup> 40 shaped torso backing materials using the microscope method outlined in Section 7.7.4.1.

### 7.8.3. Assessments

Depth of penetration measurements from each knife and spike strike shall be assessed against the limits outlined in Table 13.

### 7.8.4. Records

The following information shall be recorded after each strike has been conducted and included in the test report:

- Time at which strike performed.
- Velocity measured  $25 \pm 2$  mm from the surface, measured in  $\text{m}\cdot\text{s}^{-1}$  to two decimal places.
- Energy, measured in joules to one decimal place.
- Any spike perforation (if applicable).

After all strikes have been conducted, the following information shall be recorded and included in the test report:

- Cut length of each knife strike (where below specified limits), measured using digital microscope in millimetres to two decimal places.<sup>33</sup>
- Depth of knife penetration, recorded in millimetres to two decimal places.
- Mean velocity from all strikes in test series, recorded in  $\text{m.s}^{-1}$  to one decimal place.
- Mean energy from all strikes in test series, recorded in joules to one decimal place.

## 7.9. Additional stab tests

Additional test strikes may be performed at perceived points of weakness on the protective panels. The test facility is authorised to identify potential points of weakness for testing purposes on CAST's authorisation. CAST may also instruct the test facility to conduct tests on specific locations of the panel, which will be determined on review of the technical file.

## 7.10. Extended coverage panels

### 7.10.1. Test configuration

Extended coverage panels shall be mounted onto a conditioned, calibrated composite stab backing material pack for unformed armour in the same manner as outlined in Section 7.7.

### 7.10.2. Marking of panels

A large and a small panel shall be provided tested for each protection type (e.g. two large and two small panels would be required for KR1+SP1 extended coverage panels).

Panels shall be marked in the same positions as outlined for ballistic testing (Section 6.10.2). All strikes shall be aligned at a  $0^\circ$  angle with the long axis of the panel (Figure 26).

As described in Section 6.10.2, on panels where there is a tapering or change in width greater than 50% in the largest section (e.g. shoulder), additional strikes shall be taken. Should the manufacturer decide not to test the performance of this tapered zone, an area of full protection, defined by the manufacturer, shall be clearly marked on the product and be visible to the wearer (Figure 21).

### 7.10.3. Test methods

Unless otherwise specified, a single strike shall be conducted on the centre of the panel at the E1 energy level. Tests and associated measurements shall be conducted in accordance with methods outlined for stab testing of unformed armour in Section 7.7.

### 7.10.4. Assessments

Depth of penetration measurements from each knife and spike strike shall be assessed against the limits outlined in Table 13.

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<sup>33</sup> A digital image of each cut length, taken using the microscope, shall be stored on record.



### 7.10.5. Records

The following information shall be recorded after each strike has been conducted and included in the test report:

- Time at which strike performed.
- Velocity measured 25 ± 2 mm from the surface, measured in m.s<sup>-1</sup> to one decimal place.
- Energy, measured in joules to one decimal place.
- Ruler measurement for depth of knife penetration (where over specified limits), measured in millimetres to one decimal place.
- Any spike perforation (if applicable).

After all strikes have been conducted, the following information shall be recorded and included in the test report:

- Cut length of each knife strike (where below specified limits), measured using digital microscope in millimetres to two decimal places.<sup>34</sup>
- Depth of knife penetration, recorded in millimetres to two decimal places.
- Mean velocity from all strikes in test series, recorded in m.s<sup>-1</sup> to one decimal place.
- Mean energy from all strikes in test series, recorded in joules to one decimal place.

### 7.11. Reporting

Reporting of stab tests shall follow the template provided by CAST.<sup>35</sup> This completed report shall be sent to CAST alongside any associated relevant information (e.g. photographs) on completion of tests.

All test reports will be protectively marked as 'OFFICIAL SENSITIVE [COMMERCIAL]' with handling instructions 'for use by the Home Office, stated manufacturer and stated test facility only, unless otherwise agreed by all parties' and kept on record for a minimum of five years.

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<sup>34</sup> A digital image of each cut length, taken using the microscope, shall be stored on record.

<sup>35</sup> To be issued to test facilities in a separate file, as required.

## 8. Construction assessments

### 8.1. General requirements

On completion of the ballistic and/or stab testing, all submitted protective panels shall be assessed by the test facility to ensure the construction is the same as declared in the redacted technical file (Section 3.6.3).

Any discrepancies shall be recorded and reported to CAST and the manufacturer. Should these discrepancies be deemed significant by CAST, the protective panels shall be sent to CAST for checks.

Following construction assessments, the test facility shall store the panels for a period of six months post certification at which point they shall be returned to the manufacturer.

CAST reserves the right to request any sample from the test facility for audit checks.

### 8.2. Construction assessments

Following testing, each protective panel shall be removed from its cover and, where possible, physically separated to expose the individual material layers.<sup>36</sup> At this stage, the construction methods and, where applicable, stitching patterns detailed in the technical file shall be assessed. Subsequently, the materials and layer constructions shall be assessed against those specified in the technical file.

Any irregularities in construction shall be photographed and reported to CAST.

### 8.3. Reporting

Details from the construction assessments shall be recorded in the template provided by CAST<sup>37</sup> along with any associated relevant information (e.g. photographs). This spreadsheet shall be submitted with test reports on completion of testing.

All test reports will be protectively marked as 'OFFICIAL SENSITIVE [COMMERICAL]' with handling instructions 'for use by the Home Office, stated manufacturer and stated test facility only, unless otherwise agreed by all parties' and kept on record for a minimum of five years.

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<sup>36</sup> In instances where an adhesive has been used and it is not possible to separate the layers, a visual assessment of construction shall be conducted.

<sup>37</sup> Available on request to CAST.

## 9. Additional assessments

### 9.1. General requirements

All additional assessments are optional; they may only be performed on certified armours. Testing shall be conducted in accordance with PQT submission requirements, test methods and assessment criteria (Section 10). All testing must be conducted at a CAST accredited independent test facility (Appendix C).

### 9.2. Pre-conditioning

#### 9.2.1. Wet testing

The cover of a body armour protective panel submitted for wet testing shall be cut on the body side from the centre neck line to the base. The armour shall then be submerged vertically in de-ionised water at 15 to 20°C for a period of  $15 \pm 3$  min. The specimen shall then be removed and hung vertically with minimal support for 5 minutes in an area complying with the conditions in Section 6.4.1 prior to testing. The first shot shall be conducted within 5 minutes of the end of the drying period and the final shot no more than 45 minutes later.

#### 9.2.2. Extreme temperature testing

Protective panels submitted for extreme temperature testing shall be pre-conditioned in an environmental chamber for  $24 \pm 2$  hours at either:

- $50 \pm 5^\circ\text{C}$
- $-20 \pm 2^\circ\text{C}$

Following pre-conditioning, the protective panels shall be removed from the environmental chamber and hung in an environment complying with the conditions specified in Section 6.4.1 for  $30 \pm 5$  minutes prior to testing. The first shot shall be conducted within 5 minutes of the end of the conditioning period and the final shot no more than 45 minutes later.

### 9.3. Reporting

On completion of testing, the reports shall be sent to CAST for review alongside any associated relevant information (e.g. photographs) on completion of tests.

All test reports will be protectively marked as 'OFFICIAL SENSITIVE [COMMERICAL]' with handling instructions 'for use by the Home Office, stated manufacturer and stated test facility only, unless otherwise agreed by all parties' and kept on record for a minimum of five years.

# 10. Production quality testing

## 10.1. General requirements

PQT is a quality assurance tool designed to periodically assess the performance of certified in-production body armour and ensure it remains at its certified level. This process outlines the formal quality testing which shall be conducted at one of the CAST accredited test facilities (Appendix C).

CAST PQT checks are an independent check of a product only. It is the responsibility of the manufacturer to ensure that all armour produced performs as intended through an adequate quality assurance procedure. This must be detailed in the technical file during certification. CAST may request internal quality assurance records for a given armour model at any time.

PQT shall be performed on all certified armour at intervals outlined in Section 10.2.

Once the specified production milestones have been reached, PQT shall be submitted for assessment within a maximum time period of four weeks. All samples submitted for PQT must be taken directly from a production run.

Following PQT, test results shall be supplied to CAST for assessment and approval. CAST reserve the right to request an investigation (Section 10.9) and/or remove certification at any time if the manufacturer fails to comply with PQT or if a product fails PQT.

## 10.2. Frequency of assessment

Initial PQT assessments of any certified armour (plate, soft armour or extended coverage panel) shall be conducted in the first post-certification production run. This shall be performed at one of the CAST accredited independent test facilities.

On successful completion, the certified armour shall undergo re-assessment after two years have elapsed, effective from the date of the previous set of successful PQT tests.

## 10.3. PQT submission requirements

### 10.3.1. Quantities of armour required

The minimum submission requirements for PQT are outlined in Table 18 and Table 19. All armour shall be submitted in accordance with sizes in Section 4.3.1.

**Table 18: Quantities of armour required for ballistic PQT**

Protection level	Panel type	Size						CPA (minimum quantity – large panels)
		Small		Medium		Large		
		F	B	F	B	F	B	
HO1 or HO2	Unformed							3
	Formed	2				2		
HO3	Plate <sup>38,39</sup>			1	1			
HO4	Plate			2	1			
SG1	Plate			1	1			
<b>Extended coverage</b>		1				1		

F = front panel; B = back panel; dark grey boxes – no panels required.

**Table 19: Quantities of armour required for knife/spike PQT**

Protection level	Panel type	Size (all front)		
		Small	Medium	Large
KR1 or KR2	Unformed	1		1
	Formed	1		1
KR1 + SP1 or KR2 + SP2	Unformed	1		1
	Formed	1		1
<b>Extended Coverage</b>		1		1

### 10.3.2. Unformed armour

A minimum of three large panels are required for ballistic testing with two panels required for stab testing in accordance with the methods outlined in Section 10.5.1 and 10.6.1 respectively.

### 10.3.3. Formed armour

For formed armour, two small and two large front panels shall be submitted for ballistic testing in accordance with Section 10.5.2. For stab testing, one large and one small panel shall be submitted for testing in accordance with Section 10.6.2.

<sup>38</sup> Plates shall be supplied with associated soft armour submitted in certification.

<sup>39</sup> PQT requirements for plates intended for female end-users are given in Section 10.3.4.

Alongside this, if the formed armour has equivalent certified unformed armour of the same construction, this shall be submitted for testing in accordance with Section 10.5.1 and/or Section 10.6.1 for ballistic and stab testing respectively. If this unformed armour has been separately tested for PQT in the previous six months, additional testing is not required.

Conversely, if the formed armour does not have equivalent certified unformed armour of the same construction, an associated certified back panel of equivalent construction shall be submitted for PQT in accordance with unformed armour test methods. These unformed panels shall be produced solely for the purpose of PQT CPA assessments.

#### 10.3.4. Plates

One plate, either standalone or in conjunction with certified soft armour backing, shall be submitted for each ammunition type, tested in accordance with the methods outlined in Section 10.5.3.

If the plate is intended for female end-users, two large front plates (with certified soft armour) shall be tested on the large female Plastiline<sup>®</sup> 40 shaped backing following the test methods outlined in Section 10.5.3. Any such plate must have an equivalent certified plate tested in PQT on Roma Plastilina<sup>®</sup> No. 1 front and back male torso-shaped backing materials in accordance with the submission requirements in Table 18 and test methods outlined in Section 10.5.3. If this plate has been separately tested for PQT to these methods in the previous six months, additional testing is not required.

Each plate construction (with or without certified soft armour) shall have independent production thresholds and shall be assessed independently. The performance of the plate element in one construction does not directly affect other constructions using this plate.

#### 10.3.5. Extended coverage panels

One small and one large extended coverage panel shall be submitted for each ballistic protection level and stab protection type. These panels shall have an equivalent certified unformed armour of the same construction that has been submitted for testing in accordance with Section 10.5.1 and/or Section 10.6.1 for ballistic and stab testing respectively. If this unformed armour has been separately tested for PQT in the previous six months, additional testing is not required.

### 10.4. Pre-test checks

On submission of samples for PQT, the manufacturer shall provide a redacted technical file to the test facility, on approval by CAST. Prior to testing, armour shall undergo inspections and areal density checks in accordance with the methods in Section 5.2.1 and 5.2.2 respectively.

Areal densities shall be compared to the original certified values. If there is a deviation of greater than 5% for the whole armour, an investigation shall be commenced and areal densities of the individual layers shall be recorded to investigate following the manual method outlined in Section 5.2.2.

Inspection notes and areal densities from these assessments shall be included in PQT reports.

## 10.5. Ballistic PQT

### 10.5.1. Unformed armour

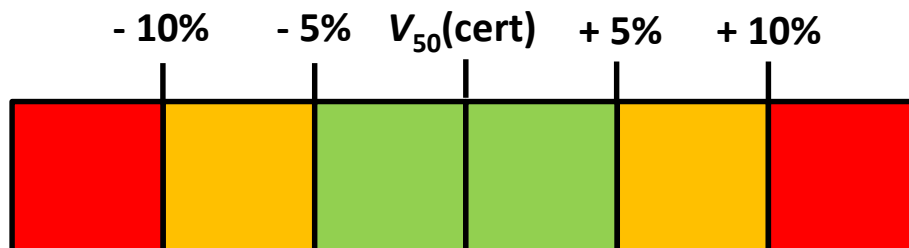
Ballistic testing for unformed armour shall comprise a CPA test. This shall be conducted in accordance with methods outlined in Section 6.8.

Results of the CPA testing shall be assessed against certification values and graded as red, amber or green based on the criteria outlined in Table 20, illustrated graphically in Figure 32.

**Table 20: Assessment criteria for unformed armour ballistic PQT**

Grading scheme	Outcome of test	Actions
<b>Red*</b>	$V_{01}$ (PQT) less than $V_{TEST}$	Immediate repeat of CPA with four additional panels. Outcome must be green. If not, batch to be held and investigation (Section 10.9) to be commenced.
<b>Red</b>	$V_{50}$ (PQT) more than 10% away from $V_{50}$ (cert)	
<b>Amber</b>	$V_{50}$ (PQT) between 5% and 10% away from $V_{50}$ (cert)	Next PQT CPA test, at specified intervals, must be green. If not, follow red grading actions.
<b>Green</b>	$V_{50}$ (PQT) less than 5% away from $V_{50}$ (cert)	Continue with next CPA at specified interval.

\* Red result regardless of  $V_{50}$  compared with  $V_{50}$  (cert). All other scores assume  $V_{01}$  is greater than  $V_{TEST}$ .



**Figure 32: Schematic showing PQT grading system from CPA tests (Percentages relate to deviation from  $V_{50}$  (cert))**

### 10.5.2. Formed armour

Formed armour ballistic PQT shall be conducted using the same procedures outlined in Section 6.6. One large and one small formed protective panel shall be used for each ammunition type. PQT results shall be assessed against the criteria outlined in Table 21.

**Table 21: Assessment criteria for formed armour ballistic PQT**

Grading scheme	Outcome of test	Actions
<b>Red</b>	Two or more perforations of the formed armour.	Investigation to be commenced (Section 10.9).
<b>Amber</b>	One perforation of the formed armour.	Immediate re-test (PQT) must be green. If not, follow red grading actions.
<b>Green</b>	No perforations of the formed armour.	Continue with next PQT at specified interval. <sup>40</sup>

These results are concomitant with those for unformed panels. If unformed panels do not meet the requirements of PQT, formed panels cannot be accredited.

### 10.5.3. Plates

PQT for plates shall comprise reduced levels of testing in accordance with Section 6.7. One plate shall be assessed per ammunition type for the certified protection level. PQT results shall conform to the requirements of certification testing (Table 8). If the results do not conform to these requirements, the batch being assessed shall be suspended and an investigation shall commence in accordance with Section 10.9.

### 10.5.4. Extended coverage panels

Extended coverage panels, submitted for ballistic testing, shall be tested in accordance with the test methods and assessment criteria outlined in Section 6.10. If the results do not conform to these requirements, the batch being assessed shall be suspended and an investigation shall commence in accordance with Section 10.9.

## 10.6. Stab PQT

### 10.6.1. Unformed armour

PQT for unformed stab resistant armour shall comprise reduced levels of testing in accordance with procedures outlined in Section 7.7. Table 22 outlines the quantities of strikes required for PQT assessment. Knife orientations for strikes have been given in brackets.

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<sup>40</sup> Based on the provision that associated unformed armour meets the requirements of Section 10.5.1.



**Table 22: Quantity of strikes for PQT assessments of unformed stab resistant armour**

		Number of strikes			
		Small panel		Large panel	
		E1	E2	E1	E2
<b>Knife only</b>		4 (0°, 30°, 45°, 90°)	2 (45°, 90°)	6 (2 x 0°, 30°, 45°, 60°, 90°)	2 (45°, 90°)
<b>Knife and spike</b>	<b>Knife</b>	4 (0°, 30°, 45°, 90°)	2 (45°, 90°)	6 (2 x 0°, 30°, 45°, 60°, 90°)	2 (45°, 90°)
	<b>Spike</b>	3	–	4	–

PQT results shall be assessed against the criteria outlined in Table 23.

**Table 23: Assessment criteria for PQT stab tests on unformed armour**

Grading scheme	Outcome of test	Actions
<b>Red</b>	One or more penetrations of a knife greater than 9 mm.	Investigation to be commenced (Section 10.9).
	More than one penetration of a spike.	
<b>Amber</b>	Two or more penetrations of a knife between 8 mm and 9 mm or one penetration of spike.	Immediate re-test (PQT) must be green. If not, investigation to be commenced (Section 10.9).
<b>Green</b>	Fully meets the requirements set out in Section 7.7.	Continue with PQT at specified interval.

### 10.6.2. Formed armour

Formed protective panels shall be marked in accordance with methods outlined in Section 7.8.2.2 following test methods outlined in Section 7.8. For knife only protection, one large panel shall be assessed in the standard formed armour strike pattern (Figure 16). For knife and spike protection, a large and a small panel shall be assessed, one each for knife and spike resistance testing. The size of panel used for each test shall be selected at the discretion of the test facility and does not always have to be the same for subsequent PQT.

The results of the formed armour stab PQT tests shall be assessed against criteria in Table 23. These results are concomitant with those for unformed panels. If unformed panels do not meet the requirements of PQT, formed panels cannot be accredited.

### 10.6.3. Extended coverage panels

Extended coverage panels, submitted for stab testing, shall be tested in accordance with the test methods and assessment criteria outlined in Section 7.10. If the results do not conform to these requirements, the batch being assessed shall be suspended and an investigation shall commence in accordance with Section 10.9.

## 10.7. Construction assessment

Following PQT, all panels shall undergo construction assessments in accordance with Section 8. Any irregularities in construction shall be photographed and reported to CAST along with the panel for inspection.

The results of these assessments shall be provided alongside PQT test reports.

## 10.8. Reporting

Reporting of PQT tests shall follow the template provided by CAST.<sup>41</sup> This completed report shall be sent to CAST alongside any associated relevant information (e.g. photographs) on completion of tests.

All test reports will be protectively marked as 'OFFICIAL SENSITIVE [COMMERICAL]' with handling instructions 'for use by the Home Office, stated manufacturer and stated test facility only, unless otherwise agreed by all parties' and kept on record for a minimum of five years.

## 10.9. PQT investigations

PQT investigations shall commence following non-conformance to PQT test requirements. In these circumstances, production of this armour shall be suspended and the PQT batch must not be sold prior to the conclusion of the investigation.

The test facility shall provide CAST and the manufacturer with results from the testing. Test panels relating to the non-conformance shall be sent to CAST.

It is the responsibility of the manufacturer to conduct an investigation and adequately satisfy CAST, with evidence supporting, of the rationale for the failed tests. The investigation shall identify and address the cause of the failure and whether other batches may have been affected.

If the cause of failure is determined and the issue relates only to the PQT batch, this may be rectified before the batch undergoes a full re-test (certification).

If the cause of failure cannot be determined and the non-conformance only relates to the PQT batch, this batch shall be quarantined/destroyed. Internal quality records shall be sought in such investigations. The next batch produced shall undergo a full re-test (certification).

If the issue relates to any other armour batches, the manufacturer shall inform customers to whom the affected armour has been sold. If the cause of failure is determined, this may be

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<sup>41</sup> To be issued to test facilities in a separate file, as required.

rectified before the batch undergoes a full re-test (certification). It is the manufacturer's responsibility to ensure that issues with any armour already distributed to their customers are rectified. Evidence of rectification shall be provided to CAST.

If, however, the cause of failure cannot be determined or rectified, the affected batches shall either be upgraded with additional protective materials (and undergo a full re-test – certification) or withdrawn. In this case, the frequency of PQT shall be increased to once every year, until satisfactory results are achieved over a period of three years.

# 11. In-life monitoring

ILM is a scheme designed to assess the continued performance of in-service armour throughout its product life expectancy. Certified body armour shall enter ILM if the manufacturer fails to provide satisfactory evidence, on submission of the technical file, of product performance for the duration of the product life expectancy (outlined in Section 3.6.1) or the manufacturer decides to opt in to the scheme.

Any armour subject to ILM, from the date of certification, shall be periodically sampled every two years throughout the duration of the product life expectancy. The initial sampling period shall begin from the date of certification. The armour shall be sampled from operational officers and shall always be the oldest in-service armours available post certification (based on serial numbers). It is the manufacturers' responsibility to acquire and replace in-service armours required for ILM. The manufacturer shall independently arrange testing at a CAST accredited independent test facility.

The selected test facility shall be responsible for conducting testing in accordance with methods outlined in this standard. After testing, test reports shall be sent to CAST for review.

The submission requirements are detailed in Table 24. Unformed armour, submitted for ballistic ILM, shall be assessed in a CPA test. A minimum of three panels shall be used in such assessment with the results being assessed against the criteria outlined in Section 10.5.1. Formed armour shall be assessed using a single panel against the criteria outlined in Section 10.5.2. One plate (with associated soft armour backings) shall be submitted per ammunition type and assessed against Section 10.5.3. For unformed armour, these panels shall be the largest available that meet the sampling criteria. Formed armour and plates shall be submitted with consideration given to the sizes of the torso mannequins for formed armour and plates, respectively (Section 4.3.1).

**Table 24: Armour submission requirements for ballistic ILM**

Protection level	Panel type	Sizes						CPA (minimum quantity – largest panels available)
		Small		Medium		Large		
		F	B	F	B	F	B	
HO1 or HO2	Unformed <sup>42</sup>							3
	Formed					1		
HO3	Plate <sup>43</sup>			2				
HO4	Plate			3				
SG1	Plate			1				

F = front panel; B = back panel; dark grey boxes – no panels required.

Unformed armour, submitted for stab ILM, shall be conducted on a single unformed protective panel assessed against the criteria outlined in Section 10.6.1. Formed armour ILM stab testing shall be conducted on a single formed front panel and assessed against the criteria outlined in Section 10.6.2. As with ballistic testing, for unformed armour, these panels shall be the largest available that meet the sampling criteria. Formed armour shall be submitted with consideration given to the sizes of female-shaped torso mannequins (Section 4.3.1).

ILM shall be conducted in accordance with the methods and assessment criteria for the respective tests outlined in PQT (Section 10). If PQT requirements are not met an investigation shall commence in accordance with Section 10.9. Additional operational armour may be required for assessment.

<sup>42</sup> Formed armour shall be assessed through associated unformed armours in a CPA test.


<sup>43</sup> Plates shall be supplied with associated soft armour submitted in certification.

# Appendix A: Declaration of construction

## Declaration of Construction of Body Armour to Home Office Body Armour Standard 2017

When completed this document will be classified

**“OFFICIAL SENSITIVE [COMMERCIAL] for use by Home Office and stated manufacturer only, unless agreed by both parties”**

<b>Manufacturer:</b>			<b>Model Reference:</b>			<b>Protection Level:</b>		
Complete details of material to be included in technical file and associated data sheets								
			Layer number			Material		
Strike Face								
								
Body Side								
Cover description								
Carrier description								

*[Manufacturer]* hereby declare that all body armour produced as model *[Armour Model Unique Identifier]* will comprise the same materials and construction as specified in the construction declaration and technical file. All armour will meet the labelling requirements in accordance with Section 3.4 of Home Office Body Armour Standard (2017) Publication No. 012/17.

Signed and dated *[Manufacturer]*:

# Appendix B: Materials data sheet: technical requirements

The following provides a guide as to the details required as part of the submission of body armour for certification testing. This data shall be supplied as an attachment for each individual material used in armour construction. Where applicable, the following information is required.

## Woven elements

Yarn:

- Fibre type
- Name (trade name and reference)
- Producer (manufacturer and specific location)
- Construction/filament count
- Twist level
- Linear density in Tex (grams per 1,000 m of yarn)

Woven fabrics:

- Material producer (manufacturer name and specific location)
- Fabric structure (e.g. plain woven)
- Areal density
- Thickness
- Material coating/surface treatments: International Union of Pure and Applied Chemistry (IUPAC) International Chemistry Identifier (InChI™)
- Quilting and construction details (e.g. orientation, spacing, stitch type, adhesives)

## Felt elements

- Felt type
- Name (trade name and reference)
- Producer (manufacturer and specific location)
- Areal density
- Thickness
- Production details

## Foam elements

- Foam type
- Name (trade name and reference)
- Producer (manufacturer and specific location)
- Density

- Thickness
- Production details

### **Thermoplastic elements**

- Thermoplastic type
- Name (trade name and reference)
- Producer (manufacturer and specific location)
- Density
- Thickness
- Material coating/surface treatments
- Adhesives used
- Production details

### **Metallic elements**

- Metal used, including alloy ratios
- Metal supplier
- Material producer (manufacturer name and specific location)
- Manufacturer's reference
- Metal hardness (Vickers scale)
- Link size (wire diameter and link internal diameter)
- Production details (e.g. welding methods)

### **Pressed fibre plate elements (e.g. UHMWPE)**

- Name (trade name and reference)
- Producer (manufacturer and specific location)
- Linear density in Tex (grams per 1,000 m of yarn)
- Layer count
- Adhesives used
- Production details

### **Ceramic elements**

- Ceramic type
- Name (trade name and reference)
- Producer (manufacturer and specific location)
- Thickness
- Density
- Hardness (Vickers scale)
- Adhesives used



# Appendix C: CAST accredited test facilities

## **Besuchssamt Mellrichstadt**

Lohstrasse 5  
97638 Mellrichstadt  
Germany

Tel: +40 (0)9776 7050-0

## **Cranfield University**

Shrivenham  
Swindon  
Wiltshire  
SN6 8LA  
England

Tel: +44 (0)1793 783192

## **HP White Laboratory Inc.**

3114 Scarboro Road Street  
Maryland  
MD 21154  
USA

Tel: +1 (410) 838 6550

## **NTS**

7447 West 33<sup>rd</sup> Street North  
Wichita  
KS 67205  
USA

Tel +1 (316) 8321 600

# Appendix D: Test equipment and consumables

Item Description	Reference	Supplier
Engineered test knife	Home Office Engineered Knife (01-07164)	Contact CAST for information
Engineered test spike	Home Office Engineered Spike (06-04419)	Contact CAST for information
Stab sabot damper discs 50 mm diameter, 30 mm thickness LD33 Plastazote® foam Water jet cut	LD33 Damper Discs	<b>Alanto Cellular Foam Solutions</b> Unit 21/23 Regal Drive Walsall Enterprise Park Walsall WS2 9HQ United Kingdom  Tel: +44 (0)1922 723740 Email: <a href="mailto:sales@alanto.co.uk">sales@alanto.co.uk</a>
Stab composite backing materials	AL52N Expanded Nitrile / NBR Sponge DK1735 Expanded Firm Neoprene Sponge Rubber LD24 Plastazote® foam AL55 solid natural rubber	<b>Alanto Cellular Foam Solutions</b> Unit 21/23 Regal Drive Walsall Enterprise Park Walsall WS2 9HQ United Kingdom  Tel: +44 (0)1922 723740 Email: <a href="mailto:sales@alanto.co.uk">sales@alanto.co.uk</a>
7.62 x 39 mm surrogate test round	PT11009	<b>EPA Manufacturing Ltd.</b> 6 Market Place Tuxford Nottinghamshire NG22 0LJ  Tel: +44 (0)1777 871310 Email: <a href="mailto:bm@epgroupuk.com">bm@epgroupuk.com</a>

Item Description	Reference	Supplier
Shaped torso moulds	Male torso front mould: 454-20753M-001-01  Male torso rear mould: 454-20753M-011-01  Large female torso mould: 454-20753M-021-01  Small female torso mould: 454-20753M-031-01	<b>Forward Composites Ltd.</b> Forward House 9-10 Clifton Road Huntingdon Cambridgeshire PE29 7EJ United Kingdom  Tel: +44 (0)1480 432623 Email: <a href="mailto:info@forwardcomposites.com">info@forwardcomposites.com</a>

Item Description	Reference
<b>Polyart™ paper</b> Arbjobex Headquarters 32, Avenue Pierre Grenier Boulogne Billancourt cedex 92517 France	Standard matt white 140/75 140 g.m <sup>-2</sup> 0.175 mm thickness
<b>Roma Plastilina® No. 1</b> Sculpture House Inc. 3804 Crossroads Parkway Fort Pierce FL 34945 USA	Grey-Green 2lb blocks
<b>Plastiline® 40</b> Herbin-Seuer SA G-Lalo 138 Quai de Jemmapes 75010 Paris France	5 kg tubes (Ivory)

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